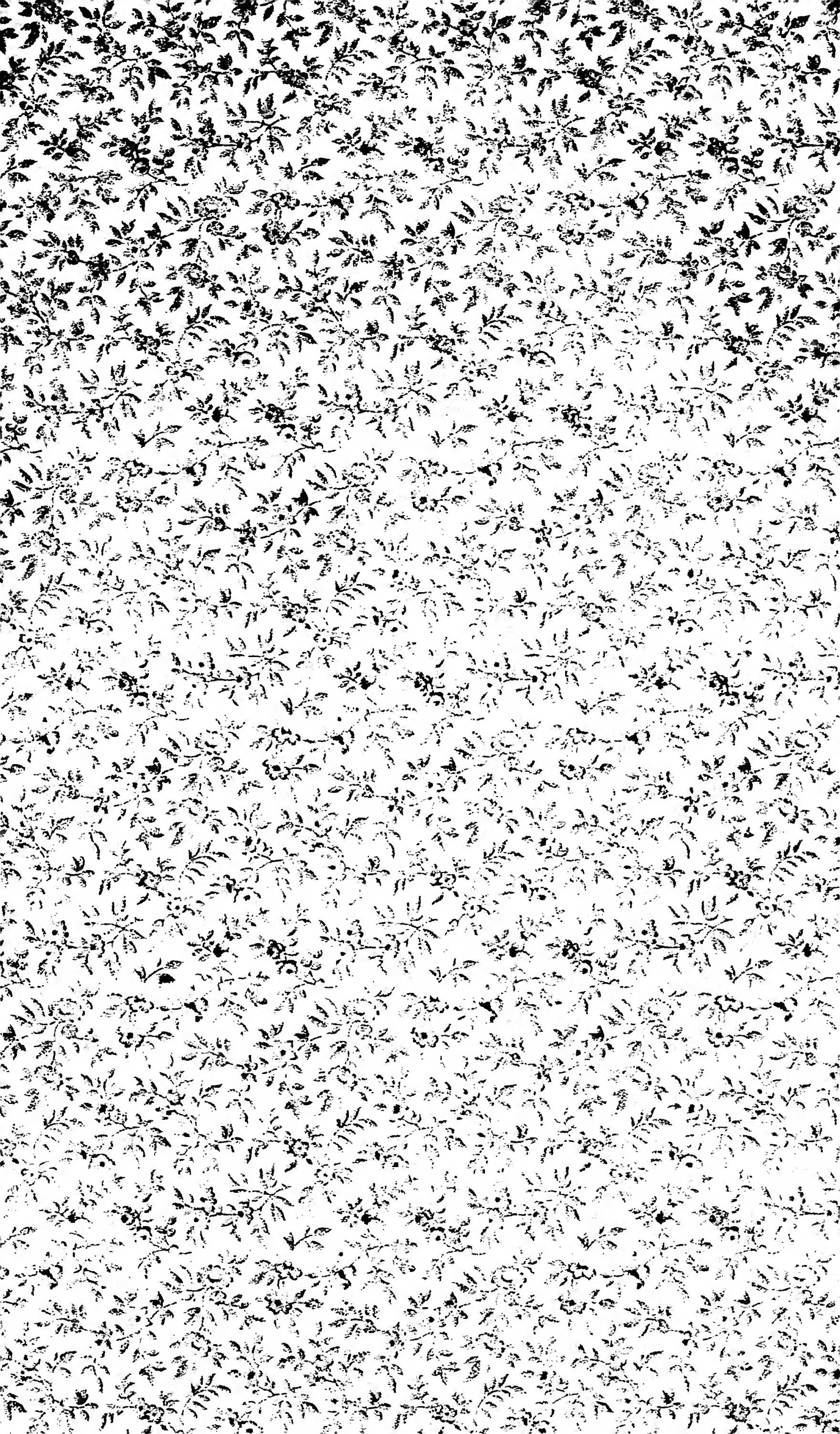

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SIR JOHN LUBBOCK.

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METHODS AND PROFIT OF TREE-PLANTING.

By N. H. EGLESTON.

THE recent calamitous fire in Michigan calls attention afresh to the rapid consumption of our forests, and occasions renewed inquiry as to what may be done either to check that consumption or to make good the loss thereby sustained. More than fifty townships of land, covering an area of about two thousand square miles, or a territory nearly half as large as the State of Connecticut, were swept over by the flames. "Scarcely a green sprig," says a reporter, "was left in the track of the fire." This fire was, indeed, exceptional in extent, as well as in the loss of life occasioned by it; and yet it was only the emphasized form of a very common occurrence—one so common that we fail to notice it as we should, or become sensible of the aggregate losses resulting therefrom. The destruction of the great pine-forests of the Northwest, of Michigan and Wisconsin, rapidly as it is carried forward by the lumberman's axe, is hastened by the fires lighted, in some cases, by the lumberman's carelessness or that of others, and in other cases as the speediest way of clearing the ground for agricultural use. There is no part of our country exempt from the destructive effects of forest-fires. The mountains and hill-sides of New England frequently show blackened spaces on their verdant flanks. The same is true of the great wooded regions of New York and Pennsylvania. The vast Adirondack forests are visited by fires, the frequency and extent of which are known to hardly any but the wandering trappers and hunters whose camp-fires, left unextinguished, may have lighted them. New Jersey has suffered severely from the burning of her woods. Ten thousand acres, covering a space seven miles in breadth, were swept over at one time, in 1866. In 1871 two fires in Ocean County consumed over thirty thousand acres, and it is said that this whole county is overrun

by fires as often as once in twenty years. In the southern part of the State, so frequent are the fires and so wide-spread, the risk has made woodland less salable than formerly. Though nine tenths of this region is wooded, there is little large timber to be found, and lumber is largely brought from distant places. Droughts are becoming more frequent, and these increase the exposure to fire. Thus the partial consumption of the forests makes their further consumption the more certain and rapid.

And what is true in this limited area is measurably true throughout the country. That our forests are being destroyed with alarming rapidity admits of no question, and it is probably true that fires consume more than are cut down by the axe of the lumberman and the wood-chopper.

Our neighbors in Canada keep themselves better informed in regard to the condition of their forests than we are in regard to our own. The Commissioner of Crown Lands, in the province of Quebec, in his report of 1871, speaking of the preservation of timber-lands, says: "The most formidable agent in the destruction of our forests is, certainly, fire. All the most active operations in lumbering which have taken place since the settlement of the country, and all those which are likely to take place for the next twenty years, have not caused, and will not cause, to our forests so much devastation as this one destroying element has effected up to the present time." In a report on forestry and the forests of Canada, by a member of the Dominion Council of Agriculture, in 1877, it is estimated that more pine-timber has been destroyed by fire than has been cut down and taken out by the lumbermen.

The combined effect of fires and the wasteful consumption of our forests in the production of lumber and for other purposes, and the almost total neglect to protect their growth, have resulted in the diminution of our area of woodland to such an extent as justly to occasion alarm on many accounts. In California, for instance, the President of the State Board of Agriculture reported, several years ago, that within twenty years at least a third of the native supply of accessible timber had been cut off or destroyed, and that forty years would exhaust the forests. This estimate was made without taking into account the increased demands upon the forests which would be made by the increase of population and the growth of manufacturing industries.

Similar reports come from other States and Territories, though in those which were originally heavily wooded the destruction of the trees may not have gone so far as to produce a scarcity of lumber, or to increase its price to such an extent as to be burdensome. In some parts of the country, also, particularly in the older States, it is probable that the growth of the woods has kept pace with their destruction. Yet of the country as a whole it may be said, without hesitation, that

the supply of desirable timber, both pine and hard-wood, has materially diminished within the last twenty-five years. As a natural consequence, the price has everywhere advanced, and a further advance is as natural and inevitable, unless effective measures are taken to check the waste of our forests and to restore them to their proper dimensions. The necessity of vigorous action in regard to this matter is beginning to be felt. In the sparsely wooded districts of the West this is particularly true. The Legislatures and agricultural societies of several of the States have already taken important action on the subject. Laws have been enacted for the protection of the existing forests from destruction by fires, and for encouraging the planting of trees. The national Congress has also, within a few years, made enactments both for the repression of timber-thieving on the public lands and to encourage the planting of timber-trees.

The enactments of Congress for the purpose of encouraging timber-planting, while they have marked a step in the right direction, have not been so effective as they might have been. This has resulted in part through evasion of the laws by speculators, who have only made a pretense of planting while their real object was to get possession of land which they could sell at a profit for agricultural purposes, and in part because the requisitions of the law were too onerous to be complied with by settlers without capital. The latter was of course unintentional. But this, as well as other defects of the timber-culture acts, came as the natural result of our ignorance in this country of the whole matter of tree-planting. We know enough to plant apple and peach trees in orchards, and a row of maples or elms, occasionally, along the road-side, for shade and ornament. But of the cultivation of trees on the large scale, in masses, as they grow in the native forests, few among us know anything. A planted forest is a thing almost unknown here. The chances are that, among the members of Congress who framed the timber-culture acts, not one had any practical knowledge of the subject. The whole matter is new to us, and we have hardly any experience for our guide. For our knowledge we must go abroad, where the subject is treated with the greatest and most scientific attention, as we have lately shown ("Popular Science Monthly," July, 1881). In France and Germany, and other European countries, one of the principle bureaus of government is that having charge of the forests and rivers. Its annual reports are looked for and read with interest, as having important bearings upon the revenue as well as upon the health of the people and the agricultural and commercial resources of the country.

It is a happy thing for us that, as we are waking up to the necessity not only of checking the wasteful consumption of our existing forests but of planting new ones, we have the experience and careful study of the subject by European nations to aid us. For, although their physical conditions are in many respects different from our own,

so that we can not adopt their methods without modification, yet certain great principles and facts have been established which are as applicable to use here as they are there.

The first, the fundamental point in tree-planting on a large scale, that is, in planting what may be called a forest, is to consider the trees as a Crop, like any other crop, only this requires a much longer time than ordinary crops to come to maturity. This will at once put the subject to many if not to most persons in a new aspect. Accepting the idea that trees are to be planted like corn or wheat, as a crop, there follows at once the necessity of care and cultivation and the consideration that these are the conditions of success. We do not expect to harvest an ordinary crop, and one that will yield a satisfactory pecuniary return, without having bestowed upon it care and labor. No more should we look for success in the larger growths of the forest without a corresponding culture. And when we come to look upon the growth of a forest in this light we shall easily, almost inevitably, regard our ordinary native forests, where the trees are simply suffered to grow up in complete neglect, exposed to injury from the intrusions of cattle and from other causes, as at best only a partial utilization of the fields which Nature has provided for our comfort and profit. It is true that trees will grow and come to maturity in rough places and on poor soils, where nothing else will grow or where the cultivation of other crops is impracticable and unprofitable. It is true also that the growth of these great forest-crops, instead of impoverishing, enriches the soil. Hence there is no use of our poor and what we call waste lands, which abound more or less everywhere, at once so economical and profitable as to devote them to the growth of trees. Left to themselves, as our forests and woodlands generally are, they are remunerative. But they might be made much more remunerative. They would be, if, instead of regarding them as one of the accidental products of Nature, we were to regard them as one of our staple crops, something to be managed and cared for by us.

The proper care of a tree-crop, as of any crop, requires its protection from injury. But we have left our forests unfenced, or, if we have inclosed them, it has been not so much for the sake of excluding destructive animals from them as for the purpose of making them pasture-grounds for our cattle, where they have been free to range and feed upon whatever might please their taste. The tender buds, the green and succulent shoots, the young trees sprouted in Nature's seed-bed and started for the growth of a century, perhaps more, we have put at the disposal of the teeth and horns and trampling hoofs of cattle. This has been regarded as a cheap way of feeding these animals. But there is no fodder for cattle so expensive as forest-fodder. Grass is cheaper than trees. Sir John Sinclair, in his "Code of Agriculture," says: "A landlord had better admit his cattle into his wheat-field than among his under-wood. In the one case they only injure the crop of

one year, whereas in the other, by biting and mangling one year's shoot, mischief is done to at least three years' growth." But he has quite understated the possible if not probable damage. At the Vienna Exposition in 1873 there was a convention of forest managers from most of the European countries, and an extensive exhibition of forest products. Among these there were sections of trees taken from a forest property near Krainburg, and designed to illustrate the comparative growth of trees when properly protected and cultivated and when exposed to browsing animals. There were shown trees which in thirty years had attained a height of only thirty inches, and others of the same age which had grown near them, but protected from animals, that were twenty-eight feet in height. The cubic contents of sixteen hundred trees, exposed and protected, were measured, with this result: in the unpastured woods, three thousand and fifty-six cubic feet; in the pastured woods, eleven. The annual increase of growth was found to be as one hundred to one, or a loss of ninety-nine per cent. of possible results. Here certainly is food for study.

In many of the ancient forests of Europe there has come down, by immemorial usage, the feudal right of the neighboring peasants to pasturage; but so injurious is the exercise of this right felt to be that the owners of the forests make it one of their chief endeavors to extinguish this right, by purchase or otherwise, whenever they can.

Again, looking upon his trees as a crop, the planter will engage in his work with a patient forecasting of the future. His success or failure does not depend upon what he may do, or fail to do, in a single season or a single year. His trees will come to maturity only with the lapse of generations. He may be planting in part for his grandchildren rather than for himself, except so far as they are himself. The pine, for example, is reckoned to come to maturity only after a growth of one hundred and sixty years. All the more need, therefore, for the adoption of a proper method, and that he should

"Learn to labor and to wait."

The European managers of forests, in forming their plantations, allow from one hundred and twenty to one hundred and sixty years as the period of growth, or of rotation, as they call it. In laying out a forest plantation they will divide the proposed tract into six or eight sections, planting one every twenty years, and, when the whole is planted, cutting and renewing a section every twenty years. Meantime there is a thinning process going on all the while, as the trees grow and require more room for their proper development. By this division of a forest into sections, they avoid the evil effects upon water-supply, climate, etc., resulting from the sweeping off of large forests at one time.

European foresters also insist strongly upon the importance of drainage for the best growth of the forest. They urge that this is

fully as important for the most rapid and healthful growth of trees as for the growth of the ordinary crops of the garden or the field. For this purpose they construct open ditches at intervals throughout the forest. In our natural forests, filled with the roots of old trees and often with rocks, it would be difficult to make such ditches. But in many of our low and swampy lands it would be quite practicable, and would add greatly to the amount and value of the growing wood. There is no reason why one should not incur the expense necessary to drain the soil for trees as readily as he does that which he considers desirable for his grass or corn; and all who undertake the planting of trees on new ground should bear this in mind.

We are writing now to urge the importance and even necessity of planting trees on the large scale, as well as the preservation and care of our existing native forests; and one of the first questions to be settled is that of the distance which should separate trees from each other at the time of planting. The experience of European planters has satisfactorily proved that they should be planted much nearer to one another than they are to stand when fully grown. In this respect they should be planted not like the apple or peach orchard, but like the corn-field. One reason why the law of Congress for the promotion of tree-culture has not been more successful is that it allowed trees to be planted twelve feet apart. Trees, when young, are delicate things, and need protection. Like human beings, they seem to have a feeling of companionship. They support and encourage one another. They thrive best when near each other. Accordingly, European foresters commonly plant trees at a distance of not more than four feet apart, and some of our Western planters are disposed to place them even closer than this. Such close planting follows the course of Nature.

If we observe a natural forest, from which destructive animals are excluded, we shall see that the ground is thickly strewed with trees—that few large vacant spaces are to be found, especially when the trees are small. As they increase in size and need more space, Nature has her own way of thinning out. The weaker decay, and the law of the survival of the fittest asserts itself. Following her guidance we have learned to plant closely, and then, from time to time, to make room for the growing trees by transplanting a portion to other fields, or by cutting them and devoting them to such uses as they are fitted for. The smaller serve for hoops for the barrel-maker, or poles for various uses. And so, at all stages of growth, there is an available and profitable use for the trees that seem to be crowding their neighbors.

It is found, again, that trees are not only social in their nature, but that they like variety in their society. As a general thing, different kinds of trees grow better when mixed together than when each kind is planted by itself. This, also, is usually Nature's way of planting. It is common, therefore, for the foresters abroad to plant what they call nurse-trees along with those which they intend to make the staple

of the ultimate and full-grown forest, the final outcome of their one hundred and twenty or one hundred and sixty years of watching and culture. If, for instance, they propose to raise what shall be at last a forest of oak-timber, they will plant with the oaks successive rows of the pine, the beech, the maple, the larch, or the birch, each at a distance perhaps of twenty feet from its own kind, but each only four feet from some neighbor. After a few years the quickest-growing trees will be removed—those nearest the oaks—and this will go on from time to time till, finally, the oaks are left to develop themselves to their fullest stature and their greatest strength. As a rule, the thinning is made at such intervals that half the trees originally planted will be removed by the time they are twenty feet high. The number on an acre should not exceed eight hundred when they have reached the height of thirty feet, and when forty feet high only three hundred or three hundred and fifty should remain. These successive thinnings, it is estimated, will more than pay for the care and labor, as well as interest on the land, leaving the final forest as clear profit. And it is to be considered that very much more valuable timber is produced on an acre of ground with this careful and systematic treatment than when a forest is left to grow up by chance and in neglect, as is so commonly the case. There is as great difference in the returns, proportionally, as there is between the yield of a vegetable-garden carefully tended and that of one left without proper cultivation and allowed to be overgrown with weeds. Dr. Berenger, head of the School of Forestry at Vallambrosa, Italy, says that "while an uncultivated woodland, taken for a long period, and counting interest and taxes, would yield almost nothing to the capital invested, it is well established that the same land, managed according to modern science, would, in the long run, yield a revenue both conspicuous and constant."

In many parts of our country, on the plains and prairies especially, and wherever tree-planting is undertaken, except for utilizing waste or rough and comparatively inaccessible ground, which would not be profitable for ordinary tillage, the most desirable mode of planting will be in belts or borders rather than in blocks. These belts should be so disposed as to serve as screens from the strongest and most hurtful winds. There can thus be secured an equally abundant growth of timber, while the screen it furnishes will greatly increase the product of other crops, and serve to promote the comfort of all, whether man or beast, who can have its shelter. The variety of products on a farm may be thus greatly increased also. Tender vegetables and fruit-trees readily flourish under the protection of such shelter belts of forest-trees which could not otherwise be cultivated with success, if at all. And the protection of such belts extends farther than many suppose. It is estimated that their beneficial influence reaches, in horizontal distance, about sixteen times their height. It is probable, therefore, that belts of trees might be so disposed, on almost any farm, that the

ground occupied by them would not diminish but rather increase the cultivable area, and the forest growth would be a positive addition to its productiveness.

But whatever the particular plan adopted, a prominent question will be with every one, what trees to plant. The multitude offering themselves for consideration is embarrassing. Our country is one of such extent and such varied climate and soil that we have a tree vegetation embracing all the variety of the entire Eastern hemisphere. Our Atlantic coast corresponds, in this respect, with that of China and Japan, while our Pacific-coast region is like that of Western Europe. At the International Exhibition at Philadelphia, in 1876, the wood of nearly four hundred indigenous species of trees was shown, whereas Great Britain has only twenty-nine; France, thirty-four; and all Europe, leaving out Russia, only about fifty. The little State of Connecticut, on the authority of Professor Brewer, has sixty species of native trees. At the Philadelphia Exhibition there were specimens of thirty-seven species of the oak, thirty-four of the pine family, seventeen of spruce and fir, eleven of maples, besides many others.

With such a variety of trees and so many conditions of climate and soil, and the different objects which the planter may have in view, no one can give an answer to the question what to plant, except in a general way. Trees have their homes as well as men, where they develop to the best. And, though they may often be transferred to other regions and be made to form to themselves new homes, the success of such a transfer can not be predicted with certainty. Experiment alone can decide. But, for the general purposes of tree-planting, and for those who are looking for definite and sure results, the safe rule, and the only trustworthy one, is to follow Nature—to plant the trees which she has already planted near us or in situations like our own. From these we may wisely make a selection, according to the objects we have mainly in view. If we want the speediest growth of fuel or shelter, we shall choose the quick-growing trees. If we purpose to grow valuable timber we shall make a different selection, or we may select for both results at the same time. Even in those parts of the country most destitute of any considerable masses of trees, the Western Plains, the treeless regions as they are called, there are a goodly number of species showing themselves, if but sparsely, and giving us hints as to what may be accomplished there in tree-planting, if fires and the depredations of destructive animals can be prevented. We have it, for example, on good authority, that the following trees, among others, are natives of Nebraska, one of the so-called treeless States: the buckeye, the red and the sugar maple, the box-elder, the honey locust, the white and green ash, two species of elm, the hackberry, sycamore, black walnut, three species of the hickory, seven species of oak, the iron-wood, two species of

birch, four of willow, the cotton-wood, the yellow pine, the red cedar, and two species of fir. Besides these trees there are many shrubs, some of which are tree-like and reach a height of twenty feet. One living where such trees are natives will hardly need to look elsewhere for trees, whether for fuel, timber, or the purposes of art and ornament. But one may also be pretty sure that where these grow other well-known and valuable trees can be successfully cultivated.

And there are some trees which are deserving of more attention than has yet been given them in this country. The willows, for instance, have seldom been cultivated in a large way; and yet there are few trees so easily grown, or which will pay better for cultivation. They adapt themselves to a wide range of soil and climate. They grow on high ground and on gravelly soils not less than by the sides of streams, where we most commonly see them. They are of rapid growth and yield a large return. The osier-willow is specially useful, we know, for the manufacture of baskets, chairs, and other articles of furniture, and we import it to the extent of $5,000,000 annually, when we might produce it easily in almost any part of our country. We hardly think of the willow as a timber-tree or for the production of lumber, but only as yielding a cheap, poor sort of fuel. But in England the wood is greatly prized for many purposes. While it is light it is also tough; it does not break into slivers. Hardly any wood is so good, therefore, for the linings of carts and wagons used in drawing stone or other rough and heavy articles. It makes excellent charcoal, especially for the manufacture of gunpowder. It bears exposure to the weather, and boards made of it are very serviceable for fences. Some species of it are admirable for use as a live fence or hedge. On account of its comparative incombustibility, the willow is eminently useful for the floors of buildings designed to be fire-proof. It grows to a large size and furnishes a great amount of lumber. There is a white willow growing in Stockbridge, Massachusetts, which, at four feet from the ground, measures twenty-two feet in circumference and extends its branches fifty feet in every direction. Tradition says it was brought from Connecticut in 1807 by a traveler, who used it as a riding-switch. The Hon. Jesse W. Fell, in giving an account of experiments in tree-planting, on an extensive scale, in Illinois, says, "Were I called upon to designate one tree which, more than all others, I would recommend for general planting, I would say unhesitatingly it should be the white willow." Professor Brewer says: "In England, where it is often sixty or seventy feet high in twenty years, there is no wood in greater demand than good willow. It is light, very tough, soft, takes a good finish, will bear more pounding and knocks than any other wood grown there, and hence its use for cricket-bats, for floats to paddle-wheels of steamers, and brake-blocks on cars. It is used extensively for turning, planking coasting-vessels, furniture, ox-yokes, wooden legs, shoe-lasts, etc." Fuller says, "It groweth incredibly fast—it being a by-

word that the profit by willows will buy the owner a horse before that by other trees will pay for the saddle." The basket-willow, well cultivated, will yield a net income of $150 a year to the acre. On the whole, therefore, it would seem that the various kinds of willow, the economic value of which has been hitherto entirely overlooked in our country, are eminently deserving of attention, and will amply reward those who cultivate them.

The ailantus and the catalpa are also deserving of much more attention than has been given them. They are both quick-growing trees, soon attaining a size fitting them for use as fuel or in the form of lumber, while they are also very tough and durable. They combine solidity with rapid growth in an unusual degree, which gives them great value to the tree-planter. The ailantus is a native of China. It was brought to this country about a hundred years ago and planted as an ornamental tree. It was for a time very popular as a shade-tree in the streets of many of our cities, but the disagreeable odor of its flowers soon destroyed its popularity, and it was cast out of good society. But, although it may not be a desirable tree for the street or the vicinity of houses, it has, as we have said, qualities which commend it to the forest-planter. The French have planted it extensively because its leaves have been found to be a welcome food to the silkworm. We may find it advantageous to plant it for the same reason, if the silk-culture is to be established in this country. The ailantus, while it grows as rapidly as the cotton-wood, produces a wood of a specific gravity nearly equal to white oak, which it resembles in color and structure, and above that of black-walnut. It has a beautiful grain, takes a high polish, is easily worked, and is an admirable wood for cabinet-work or the interior finish of houses. It will grow on almost any soil, and is easily propagated by seed or from suckers, which it throws up very abundantly. It is quite hardy as far north as a line drawn from St. Louis to Boston, and is well fitted for planting in exposed positions. Professor Sargent, of the Arnold Arboretum, Harvard University, says of it: "A careful study of the ailantus from an economic point of view, and as a subject for sylviculture, forces on me the conclusion that no other tree, either native or foreign, capable of supporting the climate of so large an area of the United States, will produce, in so short a space of time, and from land practically useless, so large an amount of valuable material—valuable alike for construction and for fuel."

The Western catalpa (*C. speciosa*), formerly little known beyond the region of the lower Ohio, except as a few specimens have been grown for the sake of their beautiful flowers, which resemble somewhat those of the horse-chestnut, has lately been found to be one of our most valuable trees. What chiefly commends it, in addition to its very rapid growth, is its remarkable durability. No tree is known to be equal to it in this respect. It seems to be almost imperishable

when exposed to moisture, and was formerly much used by the Indians for canoes. It has been a favorite material for fence and gate posts, and posts are now to be seen which have been in the ground from fifty to a hundred years, and show hardly any signs of decay. It promises to be a very valuable tree for railway-ties, and some of our railway companies, especially in the West, are planting it extensively on this account. It is also an excellent wood for the uses of the carpenter and the cabinet-maker. It resembles in color and texture the chestnut, is easily worked, and takes a fine polish. The rapidity of its growth in good soil is astonishing. A specimen from a tree which grew in Nebraska, and shows but four annual layers of growth, measured nine and three quarters inches in circumference, and the growth of the first two years was already turned to heart-wood. The tree is easily propagated from seed, and will grow anywhere south of the forty-second parallel. Specimens of it are to be found as far north as the middle of Massachusetts, and along the sea-coast as far as Maine. Wherever it can be established it will prove not only one of our most beautiful but one of our most useful woods. There are two species of catalpa indigenous to the United States; the *Speciosa*, flowering three weeks earlier than the other, a native of the South, is the hardier of the two, and preferable for planting.

As showing how practical men regard the catalpa and the ailantus, we may state that the Fort Scott and Gulf Railroad have made a contract with Messrs. Douglas, of Waukegan, to plant for them in Kansas several hundred acres of these trees. A Boston capitalist has also contracted for the planting in the same way of five hundred and sixty acres of prairie-land in Eastern Kansas. The plantation is to consist of three hundred acres of the catalpa, two hundred acres of ailantus, not less than twenty-seven hundred and twenty trees to the acre, and sixty acres are to be held as an experimental ground to be planted with several varieties of trees to be selected by Professor Sargent. What is even more noteworthy, the Iron Mountain Railroad Company, whose road runs for hundreds of miles through a heavily timbered country, have made a similar contract for planting near Charleston, Missouri, one hundred acres of the catalpa as an experiment. This they do because, while they own some of the finest white-oak timber on the continent, catalpa ties have stood on their road for twelve years entirely unaffected by decay, and the demand for ties and for posts of this wood far exceeds the present supply. It is estimated that the new railroads built in the treeless States in 1879 required over ten million ties.

The Australian eucalyptus, or blue-gum, though an Australian tree, makes itself at home in California. It is a tree of astonishingly rapid growth, yet, like the ailantus and catalpa, it produces heavy, solid wood. In a plantation of it in Alameda County, California, in seven years from planting the trees were generally ten inches in diameter

and sixty feet high. Wonderful stories are told, also, of the value of the eucalyptus as a preventive of malaria, and in reclaiming swamps by absorbing their moisture. But, whatever may or may not be true of it in these respects, the rapidity of its growth and the quality of its wood will commend its cultivation wherever it can be acclimated.

A good deal has been expected of the Scotch pine, and it has been somewhat extensively imported for the purpose of planting. In Europe it has a great reputation for the durability of its wood, and for its rapid growth on poor soils and in exposed situations. But time is seeming to prove that this tree is not well adapted to our country. It grows well for a while, and has a promising appearance while young; but, after attaining an age of from twelve to twenty years, it is apt to fail, dying off suddenly, to the great disappointment of the planter. Its most valuable use is as a nurse-tree in very exposed places, where it will shelter other and better trees until they get established and are able to take care of themselves.

But it is hardly worth while to go abroad for the Scotch pine when we have at home such a tree as the pitch-pine (*P. rigida*). This tree can be produced from seed in this country in the open field with as much certainty as a crop of corn. It has been grown for many years in this way on the barren and wind-swept soil of Cape Cod, and its cultivation has been entirely successful. Large plantations of it are to be found there, and, for the production of fuel and as a nurse for more valuable trees in such exposed and sterile situations, it has proved worthy the attention of land-holders, as it can be planted at a cost of from one to two dollars an acre.

But the white pine is the most valuable of the conifers for our Northern States. No other is equal to it as a timber-tree. The one drawback to its cultivation is the difficulty of producing it from seed in the open field. It is a tender and delicate plant at its beginning. It needs the care and shelter of the nursery. But a tree so noble when fully grown, and so valuable for many purposes, is worthy of all needed care when young, and will repay it abundantly. The tree-planter can well afford to be at the expense of transplanting this tree from the nursery. For timber, when fully grown, for shelter-belts on farms and grounds, as well as for its fine appearance on the lawn as a single tree or in clumps, our American white pine stands second to no other tree in its claims upon the attention of the planter. The rapidity with which it is being swept away by the lumberman's axe, together with its great usefulness and desirability in the arts, and especially for building purposes, will give this tree for some time to come an increasing economic value.

The European larch is quite worthy of cultivation, especially in New England. Professor Sargent says, "There is no tree capable of producing so large an amount of such valuable timber in so short a

time as the European larch, in countries where its cultivation is possible." Its cultivation has been proved possible in a large part of our country. In the East and West alike it has been planted with success, and has shown itself to be superior to the American larch, or hackmatack, as it is commonly called. It is especially adapted to poor soils, and bleak, rocky situations—emphatically a tree to be planted on waste and comparatively valueless lands. It belongs to the coniferous family of trees, though not an evergreen. It grows to a height of more than one hundred feet, and perhaps no tree combines more valuable qualities. In Europe is is especially esteemed for railway-ties. It is the most durable wood known when alternately subjected to the influence of air and water. Hence it is very valuable for piles for the construction of docks and the support of buildings. Venice is largely built upon piles made of this wood, and, though they have been exposed to the elements for hundreds of years, in many cases they show hardly any signs of decay. The European larch is more durable, as well as stronger and tougher, than oak. For posts it is probably equal to our red cedar. It is admirably adapted for the frames of buildings. Grigor, an eminent English writer on forestry, says, "No tree is so valuable as the larch in its fertilizing effects, arising from the richness of the foliage which it sheds annually." The Messrs. Fay and others have planted it extensively on Cape Cod and with great success. It has been grown all the way from there to Northwestern Iowa, and even beyond, and a village in Iowa bears the significant name "Larchmont."

An important practical question arises whether it is best to start a plantation from the seed or from trees already grown from one to three years—that is, of a size convenient for transplanting. With some kinds of trees there is little difficulty in raising them from the seed sown where they are to grow. But the preponderance of opinion both in Europe and in this country favors planting the young trees. Though so large and strong when fully grown, many trees are quite small and tender at the beginning. The stately pine, that sends its lofty spire to a height of one or even two hundred feet, is hardly visible for the first two years of its life. It is very easily destroyed. It is most economically raised, therefore, in nurseries or seed-beds, where it can have the needful protection and care. Transplanting, also, while in the nursery tends to give trees a furnishing of roots which prepares them to make a more vigorous growth than when they spring from seed on the forest-ground. It will in most cases probably be safer and cheaper for the planter to procure his trees from the professional nursery-men than to undertake himself to raise them from the seed. The European larch and Scotch pine can be imported at a cost of not more than half a cent apiece, all expenses paid. Messrs. Douglas & Sons, of Waukegan, Illinois, and other nursery-men in this country, are now raising them very largely and will furnish them at an equally cheap rate;

and there are some risks in importing trees which are avoided by purchasing those which are home-grown.

The Messrs. Douglas are probably the largest and most successful raisers of forest-tree seedlings in the United States; and, while they are sending out trees by the million, for the encouragement of farmers and others of small means who have had no experience in planting, or find it difficult to procure trees, at the suggestion of Professor Sargent, of the Arnold Arboretum, they offer to send out dollar packages of trees by mail, post-paid, to any part of the country. These packages contain each from seventy-five to a hundred forest-trees. By this means any one who has any interest in trees, or who would like to make an experiment in growing them, may at trifling cost have them delivered safely at his own door. Two years ago seventy-five thousand trees were sent out in this way as a beginning, and not a single one, it is said, failed to reach its destination in a good condition.

It may be well to make one statement in regard to planting a particular class of trees. These are the evergreens, or the conifers, including of course the larches. For shelter-belts on farms and by roadsides, and for ornamental planting near dwellings, no trees are more desirable. They commend themselves also for their bright-green foliage, holding on through the long winters which prevail over so large a portion of the country. They have been less planted than is desirable, because planting them has so often resulted in failure. This has come principally from not understanding the different nature of these trees from that of all others. The sap of the pine family is resinous and hardens whenever the bark of the roots becomes dried by exposure either to the sun or the wind, and when once hardened no application of water will dissolve it and set it flowing again. The tree is death-struck. Nothing can save it. Hence the one important thing in transplanting evergreens, whether from their native woods or from the nursery, is to keep the roots in a moist state until they are safely bedded in the ground again. This is the secret of success. This done, no trees are more easily or successfully managed. We would as soon undertake to transplant a hemlock or a pine as a currant-bush. There is no more need of failure with the one than with the other.

We have assumed all along, if we have not directly asserted, that the planting of trees on the large scale will be pecuniarily profitable, while it is, on many accounts, so desirable. We turn to this point now, however, more distinctly, because, although tree-planting is desirable for the repair of the rapid waste of our existing forests and to maintain a supply of lumber for the various uses of life, indispensable indeed, and most important also in its bearings upon climate, agricultural production, and upon all the industries and comforts of life, it is the argument of pecuniary profit upon which we must chiefly rely for any efficient action in the work of forestry. Nothing can be plainer, to any one who looks at the subject in a comprehensive way, than that

there is coming an increased demand for wood, for use as fuel and in the various arts and industries, while the sources of supply will be lessened for a long time to come, whatever may be done to increase them. The existing forests, which we are sweeping off so rapidly with the axe and by fire, have been the growth, some of them, of centuries. They can not be replaced in this generation or the next. In some cases they can not be replaced at all. Meantime the destruction of what are left will continue. It is estimated that the great lumber region of Michigan and Wisconsin will be swept of its timber in ten years more. The increasing millions of our population will make increasing demands upon the forests. With all that we may do in planting there is likely to come a scarcity of lumber and of timber for purposes of construction which will carry the price far beyond anything which we now know, and make woodlands mines of wealth to their owners.

But comparatively few take such a large view of things; or, if they do, have the forecast and resolution to act upon it. It is the consideration of present gain or loss which moves most men to action. And, regarded in this light, the subject of tree-planting is one which commends itself to almost all land-owners. Apart from the rich prairies of the West, there is hardly a farm, we may say, upon which there is not some portion so swampy, so rocky and inaccessible, or so poor in soil, that the cultivation of the ordinary crops upon it is impracticable or unprofitable. Such portions are now properly called waste-lands. But there ought to be no waste-lands. There need be none. These intractable portions of many of our farms, now bearing only a scanty and often well-nigh worthless growth, may, with little trouble, be planted with valuable trees, which, even in a few years, will yield a profitable return from their proper thinning, while those that may be left will increase in value as certainly and as rapidly as money deposited in a savings-bank or invested in the public funds. The farmer or land-owner can hardly provide for his children so easily as in this way a sure and valuable legacy. A distinguished authority has said, "As a general rule, in the highlands and lowlands of Scotland, land under wood, at the end of sixty years, under good management, will pay the proprietor nearly three times the sum of money that he would have received from any other crop on the same piece of ground."

Nothing is better understood in England and on the Continent than that the forests are among the best and surest sources of income. Governments and great corporations regard them as stable and important means of revenue. In our own country, as yet, we have not become accustomed to look upon the forests in this aspect. Nor have we cared for them as we do for those things which we depend upon for revenue. And yet, neglected as our woodlands have been, and left to take care of themselves, they have yielded a fair pecuniary return. There is no reason why, with good management, they should

not be as profitable as the Scotch plantations. We have already sufficient demonstration of this from actual experiment. We have some plantations of trees, both in the East and in the West, which are of sufficient age to furnish reliable data upon this subject. Mr. Budd, a tree-grower of Iowa, and a careful observer, says: "A grove of ten acres, thinned to six feet apart, containing twelve thousand trees, at twelve years were eight inches in diameter and thirty-four feet high, the previous thinning paying all expenses of planting and cultivation. Ten feet of the bodies of these trees were worth, for making bent-stuff, etc., forty cents each, and the remaining top ten cents, making a total of $6,000 as the profit of ten acres in twelve years, or a yearly profit of $50 per acre." Similar reports come from other places in the West.

But, turning from the rich lands of the West to the poor soils and rough exposures of the East, we have sufficient examples of the profitableness of tree-planting. One of the oldest in date, perhaps the oldest example of forest-planting in this country, is that of Mr. Zachariah Allen, at Smithfield, Rhode Island. In 1820 a tract of land forty acres in extent was bequeathed to him. Professor Sargent, from whom we take the account, says: "It had been constantly used as a pasture for nearly a hundred years previous to its coming into Mr. Allen's hands, and was at that time entirely worn out. The situation was an elevated one, and completely exposed to the wind, the forty acres occupying the summit of a high hill of granite formation. The surface was marked with ledges, cropping out in projecting cliffs, with intervals of loamy soil, covered with a scanty herbage, and supplying nourishment to a few straggling white birches and the other hardy plants which still too clearly mark our barren pastures. It was found impossible to lease the land for pasturage, so exhausted had it become. The owner consequently determined to try the experiment of planting the whole, or that portion where the rock did not come to the surface, with the seeds of forest-trees. The planting was done in 1820, and cost $45. Since then, for fifty-seven years, Mr. Allen has kept a minute account of his expenditures and receipts in connection with that field. He sets down the price of the land at fifteen dollars an acre, that being what it was appraised at in the division of the estate of the previous owner, though the taxes were for years less than two dollars and a half yearly for the whole forty acres. Charging himself with the land and with interest on its valuation, and also on the taxes paid for fifty-seven years, his debit account stood, at the close of 1877, $3,804.83. His credit account at the same time, for wood, posts, timber, etc., and 320 cords still uncut, stood $6,348.06, leaving a profit of $2,543.23, or $6\frac{92}{100}$ per cent on the investment for the whole term, and the land greatly improved besides."

The experiments of Messrs. Fay and others at Lynn, and on the barren sands of Cape Cod, where thousands of acres, valued at only

fifty cents apiece, and hardly worth that, have been planted with the native pitch and white pine, the Scotch and Austrian pine, the Norway spruce, and the European larch, are equally convincing. Mr. Fay planted in 1854, and in 1877 had one hundred and twenty-five acres densely covered with trees. The larches had reached a height of forty feet and a diameter of fourteen inches. Scotch pines, sown as late as 1861, were thirty feet high and ten inches in diameter a foot from the ground. Mr. Fay is abundantly satisfied with the results of his experiments. Professor Sargent says, speaking of the plantations made by Messrs. Fay and others: "When we consider the success which has attended the experiments of these gentlemen in reclothing their property with forest growths, under circumstances, too, as disadvantageous as it is possible for Massachusetts to offer, it must be acknowledged that the attempt to replant our unimproved lands is a perfectly feasible one; and the only wonder is that the inhabitants of Essex and Barnstable Counties, with such examples before them, have not already planted their worthless, worn-out lands with a crop which would yield a larger profit than any they have produced since the first clearing of the forest."

Taking the results of Mr. Fay's planting, and the average results of the planting of the larches in the Highlands of Scotland, which are nearly the same in like conditions, Professor Sargent finds that, on ordinary soil, larches planted when about one foot high and three years old, will in twenty years average twenty-two feet in height and seven inches in diameter three feet from the ground; and that in thirty years they will be from thirty-five to forty feet high and twelve inches in diameter; and, if thinned out, the remaining trees, at fifty years from the time of planting, will reach from sixty to seventy feet in height and at least twenty inches in diameter. On this basis he makes the estimated profit on a plantation of ten acres of larch-trees, at the end of fifty years, to be $52,282.75, or thirteen per cent per annum for the whole time. The estimate is carefully made, as would be seen, if we had space for the particulars; but with a considerable discount from the figures of Professor Sargent there is left, certainly, a reasonable profit.

It is to be remembered also that trees are not exhausting crops, but that they tend to enrich and improve the land on which they grow. If this be taken into account, the estimate of possible and probable profit from the planting of our many acres of wild, rocky, sandy, and other poor and practically waste land, is to be counted only by millions of dollars, while the benefits that would accrue from extensive tree-planting in the more equable distribution of rain and the flow of our streams, in meteorologic influences upon health and comfort, and in other ways, would be simply incalculable.

PROFESSOR GOLDWIN SMITH AS A CRITIC.

By HERBERT SPENCER.

IN the preface to the "Data of Ethics" there occurs the following sentence:

> With a view to clearness, I have treated separately some correlative aspects of conduct, drawing conclusions either of which becomes untrue if divorced from the other, and have thus given abundant opportunity for misrepresentation.

When I wrote this sentence, I little dreamed that Professor Goldwin Smith would be the man to verify my expectation more fully than I expected it to be verified by the bitterest bigot among those classed as orthodox.

I do not propose here to enter upon a controversy. I propose simply to warn readers that, before accepting Professor Goldwin Smith's versions of my views, it will be well to take the precaution of referring to the views as expressed by myself, to see whether the two correspond. And, by way of showing that this warning is called for, I will give them the opportunity of comparing representation with reality in a single instance.

In his article in the last number of this "Review," and on page 340, he characterizes the doctrine I have set forth in these words:

> An authoritative conscience, duty, virtue, obligation, principle, and rectitude of motive, no more enter into his definitions, or form parts of his system, than does the religious sanction.

Before going further, let the reader dwell a moment on this statement, and consider the full implication of its words. Let him ask himself what kind of conclusions he would look for in a system of ethics which does not recognize "an authoritative conscience"; what ideas of right and wrong are likely to be found in a treatise on conduct which excludes "duty" and "virtue"; what he thinks must be the general traits of a moral doctrine in which "principle" has no place. Then, when he has fully impressed himself with the meaning of Professor Smith's words, and imagined the kind of teaching indicated by them, let him observe the teaching he actually finds. The following passage, from chapter ix of the "Data of Ethics," will prepare the way for more specific passages:

> It is quite consistent to assert that happiness is the ultimate aim of action, and at the same time to deny that it can be reached by making it the immediate aim. I go with Mr. Sidgwick as far as the conclusion that "we must at least admit the desirability of confirming or correcting the results of such comparisons [of pleasures and pains] by any other method upon which we may find reason to rely"; and I then go further and say that, throughout a large part of conduct, guidance by such comparisons is to be entirely set aside and replaced by other guidance (pp. 155, 156).

Even without going further, it will, I think, be manifest enough that, instead of putting pleasures and pains in the foreground, as alone to be considered in determining right and wrong (which Professor Goldwin Smith's account of my views will lead every reader to suppose I do), I have here distinctly asserted the need for another method of determining right and wrong. And if comparisons of pleasures and pains, or estimations of happiness, are to be "entirely set aside" in the guidance of "a large part of conduct," it will puzzle any reader to conceive what such guidance can be if there are excluded from it all ideas of principle, rectitude, duty, obligation. But now, remarking this much, I go on to point out that a large part of the chapter is devoted to the refutation of Bentham's doctrine, that happiness is to be the immediate object of pursuit. I have insisted on the authoritative character of certain "regulative principles for the conduct of associated human beings" (p. 167), which are already recognized and "established," and have urged that conformity to these must be the direct aim, and not happiness. Concerning certain moral ideas and sentiments, I have said :

> Are they supernaturally-caused modes of thinking and feeling, tending to make men fulfill the conditions to happiness? If so, their authority is peremptory. Are they modes of thinking and feeling naturally caused in men by experience of these conditions? If so, their authority is no less peremptory (p. 168).

And then, having in various ways explained and enforced the need for these "regulative principles," and the peremptory authority of these "modes of thinking and feeling" known as conscience, I have closed the chapter by saying that "conflicting ethical theories . . . severally embody portions of the truth, and simply require combining in proper order to embody the whole truth" (p. 171).

> The theological theory contains a part. If for the divine will, supposed to be supernaturally revealed, we substitute the naturally-revealed end toward which the power manifested throughout evolution works; then, since evolution has been, and is still, working toward the highest life, it follows that conforming to those principles by which the highest life is achieved is furthering that end. The doctrine, that perfection or excellence of nature should be the object of pursuit, is in one sense true, for it tacitly recognizes that ideal form of being which the highest life implies, and to which evolution tends. There is a truth, also, in the doctrine that virtue must be the aim, for this is another form of the doctrine that the aim must be to fulfill the conditions to achievement of the highest life. That the intuitions of a moral faculty should guide our conduct is a proposition in which a truth is contained, for these intuitions are the slowly organized results of experiences received by the race while living in presence of these conditions. And that happiness as the supreme end is beyond question true, for this is the concomitant of that highest life which every theory of moral guidance has distinctly or vaguely in view.
>
> So understanding their relative positions, those ethical systems which make virtue, right, obligation the cardinal aims, are seen to be complementary to those

ethical systems which make welfare, pleasure, happiness the cardinal aims (pp. 171, 172).

Nor is this all. Having asserted that the moral sentiments "are indispensable as incentives and deterrents," and that "the intuitions corresponding to these sentiments" have "a general authority to be reverently recognized," I have ended by saying:

> Hence, recognizing in due degrees all the various ethical theories, conduct in its highest form will take as guides, innate perceptions of right, duly enlightened and made precise by an analytic intelligence, while conscious that these guides are proximately supreme solely because they lead to the ultimately supreme end—happiness, special and general (pp. 172, 173).

Experience does not lead me to suppose that Professor Goldwin Smith will admit his description of my views to be unjustified. Contrariwise, many instances have proved to me that, when the statements first made are not distinguished by great scrupulousness, no great scrupulousness is shown in the defense of them. The reader will be able, however, to decide beforehand whether any reply which may be made can be adequate. He has simply to ask himself whether, having read the sentence I have quoted from Professor Goldwin Smith, he could have expected to find in the "Data of Ethics" the passages I have quoted from it. If he says "No," as he must do, then, whatever explanation or defense may be offered, will leave outstanding the charge of grave misrepresentation.

Perhaps it will be assumed that this is simply a mistake, an inadvertence, an oversight on the part of Professor Goldwin Smith—an exceptional error he has fallen into. Well, even were this true, it could hardly be held to excuse him, considering that his statement involves a condemnatory characterization of the work as a whole. But it is not true. So far from being exceptional, the instance I have given is typical of his entire criticism. I have noted eight other statements of his concerning views of mine, which are quite at variance with the facts—most of them as widely at variance as the one I have instanced. I do not wish to occupy either my own time or the pages of the "Contemporary Review" in setting forth these at length, but I am quite prepared to do it if need be.—*Contemporary Review.*

MONKEYS.

By ALFRED RUSSEL WALLACE.

IF the skeletons of an orang-outang and a chimpanzee be compared with that of a man, there will be found to be the most wonderful resemblance, together with a very marked diversity. Bone for bone, throughout the whole structure, will be found to agree in general

form, position, and function, the only absolute differences being that the orang has nine wrist-bones, whereas man and the chimpanzee have but eight ; and the chimpanzee has thirteen pairs of ribs, whereas the orang, like man, has but twelve. With these two exceptions, the differences are those of shape, proportion, and direction only, though the resulting differences in the external form and motions are very considerable. The greatest of these are, that the feet of the anthropoid or man-like apes, as well as those of all monkeys, are formed like hands, with large opposable thumbs fitted to grasp the branches of trees, but unsuitable for erect walking, while the hands have weak small thumbs but very long and powerful fingers, forming a hook rather than a hand, adapted for climbing up trees and suspending the whole weight from horizontal branches. The almost complete identity of the skeleton, however, and the close similarity of the muscles and of all the internal organs, have produced that striking and ludicrous resemblance to man which every one recognizes in these higher apes and, in a less degree, in the whole monkey tribe ; the face and features, the motions, attitudes, and gestures being often a strange caricature of humanity. Let us, then, examine a little more closely in what the resemblance consists, and how far, and to what extent, these animals really differ from us.

Besides the face, which is often wonderfully human—although the absence of any protuberant nose gives it often a curiously infantile aspect—monkeys, and especially apes, resemble us most closely in the hand and arm. The hand has well-formed fingers with nails, and the skin of the palm is lined and furrowed like our own. The thumb is, however, smaller and weaker than ours, and is not so much used in taking hold of anything. The monkey's hand is, therefore, not so well adapted as that of man for a variety of purposes, and can not be applied with such precision in holding small objects, while it is unsuitable for performing delicate operations such as tying a knot or writing with a pen. A monkey does not take hold of a nut with its forefinger and thumb as we do, but grasps it between the fingers and the palm in a clumsy way, just as a baby does before it has acquired the proper use of its hand. Two groups of monkeys—one in Africa and one in South America—have no thumbs on their hands, and yet they do not seem to be in any respect inferior to other kinds which possess it. In most of the American monkeys the thumb bends in the same direction as the fingers, and in none is it so perfectly opposed to the fingers as our thumbs are ; and all these circumstances show that the hand of the monkey is, both structurally and functionally, a very different and very inferior organ to that of man, since it is not applied to similar purposes, nor is it capable of being so applied.

When we look at the feet of monkeys we find a still greater difference, for these have much larger and more opposable thumbs, and are, therefore, more like our hands ; and this is the case with all monkeys,

so that even those which have no thumbs on their hands, or have them small and weak and parallel to the fingers, have always large and well-formed thumbs on their feet. It was on account of this peculiarity that the great French naturalist Cuvier named the whole group of monkeys Quadrumana, or four-handed animals, because, besides the two hands on their fore-limbs, they have also two hands in place of feet on their hind-limbs. Modern naturalists have given up the use of this term, because they say that the hind extremities of all monkeys are really feet, only these feet are shaped like hands; but this is a point of anatomy, or rather of nomenclature, which we need not here discuss.

Let us, however, before going further, inquire into the purpose and use of this peculiarity, and we shall then see that it is simply an adaptation to the mode of life of the animals which possess it. Monkeys, as a rule, live in trees, and are especially abundant in the great tropical forests. They feed chiefly upon fruits, and occasionally eat insects and birds'-eggs, as well as young birds, all of which they find in the trees; and, as they have no occasion to come down to the ground, they travel from tree to tree by jumping or swinging, and thus pass the greater part of their lives entirely among the leafy branches of lofty trees. For such a mode of existence, they require to be able to move with perfect ease upon large or small branches, and to climb up rapidly from one bough to another. As they use their hands for gathering fruit and catching insects or birds, they require some means of holding on with their feet, otherwise they would be liable to continual falls, and they are able to do this by means of their long finger-like toes and large opposable thumbs, which grasp a branch almost as securely as a bird grasps its perch. The true hands, on the contrary, are used chiefly to climb with, and to swing the whole weight of the body from one branch or one tree to another, and for this purpose the fingers are very long and strong, and in many species they are further strengthened by being partially joined together, as if the skin of our fingers grew together as far as the knuckles. This shows that the separate action of the fingers, which is so important to us, is little required by monkeys, whose hand is really an organ for climbing and seizing food, while their foot is required to support them firmly in any position on the branches of trees, and for this purpose it has become modified into a large and powerful grasping hand.

Another striking difference between monkeys and men is, that the former never walk with ease in an erect posture, but always use their arms in climbing or in walking on all-fours like most quadrupeds. The monkeys that we see in the streets, dressed up and walking erect, only do so after much drilling and teaching, just as dogs may be taught to walk in the same way; and the posture is almost as unnatural to the one animal as it is to the other. The largest and most man-like of the apes—the gorilla, chimpanzee, and orang-outang—also

walk usually on all-fours; but in these the arms are so long and the legs so short that the body appears half erect when walking; and they have the habit of resting on the knuckles of the hands, not on the palms like the smaller monkeys, whose arms and legs are more nearly of an equal length, which tends still further to give them a semi-erect position. Still, they are never known to walk of their own accord on their hind-legs only, though they can do so for short distances, and the story of their using a stick and walking erect by its help in the wild state is not true. Monkeys, then, are both four-handed and four-footed beasts; they possess four hands formed very much like our hands, and capable of picking up or holding any small object in the same manner; but they are also four-footed, because they use all four limbs for the purpose of walking, running, or climbing; and, being adapted to this double purpose, the hands want the delicacy of touch and the freedom as well as the precision of movement which ours possess. Man alone is so constructed that he walks erect with perfect ease, and has his hands free for any use to which he wishes to apply them; and this is the great and essential bodily distinction between monkeys and men.

We will now give some account of the different kinds of monkeys and the countries they inhabit.

The Different Kinds of Monkeys and the Countries they inhabit.—Monkeys are usually divided into three kinds—apes, monkeys, and baboons; but these do not include the American monkeys, which are really more different from all those of the Old World than any of the latter are from each other. Naturalists, therefore, divide the whole monkey-tribe into two great families, inhabiting the Old and the New Worlds respectively; and, if we learn to remember the kind of differences by which these several groups are distinguished, we shall be able to understand something of the classification of animals, and the difference between important and unimportant characters.

Taking first the Old World groups, they may be thus defined: apes have no tails; monkeys have tails, which are usually long; while baboons have short tails, and their faces, instead of being round and with a man-like expression as in apes and monkeys, are long and more dog-like. These differences are, however, by no means constant, and it is often difficult to tell whether an animal should be classed as an ape, a monkey, or a baboon. The Gibraltar ape, for example, though it has no tail, is really a monkey, because it has callosities, or hard pads of bare skin on which it sits, and cheek-pouches in which it can stow away food; the latter character being always absent in the true apes, while both are present in most monkeys and baboons. All these animals, however, from the largest ape to the smallest monkey, have the same number of teeth as we have, and they are arranged in a similar manner, although the tusks, or canine teeth, of the males are often large, like those of a dog.

The American monkeys, on the other hand, with the exception of the marmosets, have four additional grinding-teeth (one in each jaw on either side), and none of them have callosities or cheek-pouches. They never have prominent snouts like the baboons; their nostrils are placed wide apart and open sideways on the face; the tail, though sometimes short, is never quite absent; and the thumb bends the same way as the fingers, is generally very short and weak, and is often quite wanting. We thus see that these American monkeys differ in a great number of characters from those of the Eastern hemisphere; and they have this further peculiarity, that many of them have prehensile or grasping tails, which are never found in the monkeys of any other country. This curious organ serves the purpose of a fifth hand. It has so much muscular power that the animal can hang by it easily with the tip curled round a branch, while it can also be used to pick up small objects with almost as much ease and exactness as an elephant's trunk. In those species which have it most perfectly formed it is very long and powerful, and the end has the under-side covered with bare skin, exactly resembling that of the finger or palm of the hand, and apparently equally sensitive. One of the common kinds of monkeys that accompany street organ-players has a prehensile tail, but not of the most perfect kind; since in this species the tail is entirely clad with hair to the tip, and seems to be used chiefly to steady the animal when sitting on a branch by being twisted round another branch near it. The statement is often erroneously made that all American monkeys have prehensile tails; but the fact is that rather less than half the known kinds have them so, the remainder having this organ either short and bushy or long and slender, but entirely without any power of grasping. All prehensile-tailed monkeys are American, but all American monkeys are not prehensile-tailed.

By remembering these characters it is easy, with a little observation, to tell whether any strange monkey comes from America or from the Old World. If it has bare seat-pads, or if when eating it fills its mouth till its cheeks swell out like little bags, we may be sure it comes from some part of Africa or Asia; while, if it can curl up the end of its tail so as to take hold of anything, it is certainly American. As all the tailed monkeys of the Old World have seat-pads (or ischial callosities as they are called in scientific language), and as all the American monkeys have tails, but no seat-pads, this is the most constant external character by which to distinguish them; and, having done so, we can look for the other peculiarities of the American monkeys, especially the distance apart of the nostrils and their lateral position.

The whole monkey-tribe is especially tropical, only a few kinds being found in the warmer parts of the temperate zone. One inhabits the Rock of Gibraltar, and there is one very like it in Japan, and these are the two monkeys which live farthest from the equator. In the

tropics they become very abundant, and increase in numbers and variety as we approach the equator, where the climate is hot, moist, and equable, and where flowers, fruits, and insects are to be found throughout the year. Africa has about fifty-five different kinds, Asia and its islands about sixty, while America has one hundred and fourteen, or almost exactly the same as Asia and Africa together. Australia and its islands have no monkeys, nor has the great and luxuriant Island of New Guinea, whose magnificent forests seem so well adapted for them. We will now give a short account of the different kinds of monkeys inhabiting each of the tropical continents.

Africa possesses two of the great man-like apes—the gorilla and the chimpanzee, the former being the largest ape known, and the one which, on the whole, perhaps most resembles man, though its countenance is less human than that of the chimpanzee. Both are found in West Africa, near the equator, but they also inhabit the interior wherever there are great forests; and Dr. Schweinfurth states that the chimpanzee inhabits the country about the sources of the Shari River, in 28° east longitude and 4° north latitude.

The long-tailed monkeys of Africa are very numerous and varied. One group has no cheek-pouches and no thumb on the hand, and many of these have long, soft fur of varied colors. The most numerous group are the guenons, rather small, long-tailed monkeys, very active and lively, and often having their faces curiously marked with white or black, or ornamented with whiskers or other tufts of hair; and they all have large cheek-pouches and good-sized thumbs. Many of them are called green monkeys, from the greenish-yellow tint of their fur, and most of them are well-formed, pleasing animals. They are found only in tropical Africa.

The baboons are larger, but less numerous. They resemble dogs in the general form and the length of the face or snout, but they have hands with well-developed thumbs on both the fore and hind limbs; and this, with something in the expression of the face, and their habit of sitting up and using their hands in a very human fashion, at once shows that they belong to the monkey-tribe. Many of them are very ugly, and in their wild state they are the fiercest and most dangerous of monkeys. Some have the tail very long, others of medium length, while it is sometimes reduced to a mere stump, and all have large cheek-pouches and bare seat-pads. They are found all over Africa, from Egypt to the Cape of Good Hope; while one species, called the hamadryas, extends from Abyssinia across the Red Sea into Arabia, and is the only baboon found out of Africa. This species was known to the ancients, and it is often represented in Egyptian sculptures, while mummies of it have been found in the catacombs. The largest and most remarkable of all the baboons is the mandrill of West Africa, whose swollen and hog-like face is ornamented with stripes of vivid blue and scarlet. This animal has a tail scarcely two inches

long, while in size and strength it is not much inferior to the gorilla. These large baboons go in bands, and are said to be a match for any other animals in the African forests, and even to attack and drive away the elephants from the districts they inhabit.

Turning now to Asia, we have first one of the best known of the large man-like apes—the orang-outang, found only in the two large islands, Borneo and Sumatra. The name is Malay, signifying "man of the woods," and it should be pronounced órang-óotang, the accent being on the first syllable of both words. It is a very curious circumstance that, whereas the gorilla and chimpanzee are both black, like the negroes of the same country, the orang-outang is red or reddish-brown, closely resembling the color of the Malays and Dyaks who live in the Bornean forests. Though very large and powerful, it is a harmless creature, feeding on fruit, and never attacking any other animal except in self-defense. A full-grown male orang-outang is rather more than four feet high, but with a body as large as that of a stout man, and with enormously long and powerful arms.

Another group of true apes inhabit Asia and the larger Asiatic islands, and are in some respects the most remarkable of the whole family. These are the gibbons, or long-armed apes, which are generally of small size and of a gentle disposition, but possessing the most wonderful agility. In these creatures the arms are as long as the body and legs together, and are so powerful that a gibbon will hang for hours suspended from a branch, or swing to-and-fro, and then throw itself a great distance through the air. The arms, in fact, completely take the place of the legs for traveling. Instead of jumping from bough to bough, and running on the branches, like other apes and monkeys, the gibbons move along while hanging suspended in the air, stretching their arms from bough to bough, and thus going hand over hand as a very active sailor will climb along a rope. The strength of their arms is, however, so prodigious, and their hold so sure, that they often loose one hand before they have caught a bough with the other, thus seeming almost to fly through the air by a series of swinging leaps; and they travel among the net-work of interlacing boughs a hundred feet above the earth with as much ease and certainty as we walk or run upon level ground, and with even greater speed. These little animals scarcely ever come down to the ground of their own accord; but, when obliged to do so, they run along almost erect, with their long arms swinging round and round, as if trying to find some tree or other object to climb upon. They are the only apes who naturally walk without using their hands as well as their feet; but this does not make them more like men, for it is evident that the attitude is not an easy one, and is only adopted because the arms are habitually used to swing by, and are therefore naturally held upward instead of downward, as they must be when walking on them.

The tailed monkeys of Asia consist of two groups, the first of which

have no cheek-pouches, but always have very long tails. They are true forest monkeys, very active, and of a shy disposition. The most remarkable of these is the long-nosed monkey of Borneo, which is very large, of a pale-brown color, and distinguished by possessing a long, pointed, fleshy nose, totally unlike that of all other monkeys. Another interesting species is the black and white entellus monkey of India, called "Hanuman" by the Hindoos, and considered sacred by them. These animals are petted and fed, and at some of the temples numbers of them come every day for the food which the priests, as well as the people, provide for them.

The next group of Eastern monkeys are the Macaques, which are more like baboons, and often run upon the ground. They are more bold and vicious than the others. All have cheek-pouches, and though some have long tails, in others the tail is short, or reduced to a mere stump. In some few this stump is so very short that there appears to be no tail, as in the magot of North Africa and Gibraltar, and in an allied species that inhabits Japan.

AMERICAN MONKEYS.—The monkeys which inhabit America form three very distinct groups: 1. The Sapajous, which have prehensile or grasping tails; 2. The Sagouins, which have ordinary tails, either long or short; and, 3. The Marmosets, very small creatures, with sharp claws, long tails, which are not prehensile, and a smaller number of teeth than all other American monkeys. Each of these three groups contains several sub-groups, or *genera*, which often differ remarkably from each other, and from all the monkeys of the Old World.

We will begin with the howling monkeys, which are the largest found in America, and are celebrated for the loud voice of the males. Often in the great forests of the Amazon, or Orinoco, a tremendous noise is heard in the night or early morning, as if a great assemblage of wild beasts were all roaring and screaming together. The noise may be heard for miles, and it is louder and more piercing than that of any other animals, yet it is all produced by a single male howler sitting on the branches of some lofty tree. They are enabled to make this extraordinary noise by means of an organ that is possessed by no other animal. The lower jaw is unusually deep, and this makes room for a hollow bony vessel about the size of a large walnut, situated under the root of the tongue, and having an opening into the windpipe by which the animal can force air into it. This increases the power of its voice, acting something like the hollow case of a violin, and producing those marvelous rolling and reverberating sounds which caused the celebrated traveler Waterton to declare that they were such as might have had their origin in the infernal regions. The howlers are large and stout-bodied monkeys with bearded faces, and very strong and powerfully grasping tails. They inhabit the wildest forests; they are very shy, and are seldom taken captive, though they are less active than many other American monkeys.

Next come the spider-monkeys, so called from their slender bodies and enormously long limbs and tail. In these monkeys the tail is so long, strong, and perfect, that it completely takes the place of a fifth hand. By twisting the end of it round a branch the animal can swing freely in the air with complete safety; and this gives them a wonderful power of climbing and passing from tree to tree, because the distance they can stretch is that of the tail, body, and arm added together, and these are all unusually long. They can also swing themselves through the air for great distances, and are thus able to pass rapidly from tree to tree without ever descending to the ground, just like the gibbons in the Malayan forests. Although capable of feats of wonderful agility, the spider-monkeys are usually slow and deliberate in their motions, and have a timid, melancholy expression, very different from that of most monkeys. Their hands are very long, but have only four fingers, being adapted for hanging on to branches rather than for getting hold of small objects. It is said that, when they have to cross a river the trees on the opposite banks of which do not approach near enough for a leap, several of them form a chain, one hanging by its tail from a lofty overhanging branch and seizing hold of the tail of the one below it, then gradually swinging themselves backward and forward till the lower one is able to seize hold of a branch on the opposite side. He then climbs up the tree, and, when sufficiently high, the first one lets go, and the swing either carries him across to a bough on the opposite side or he climbs up over his companions.

Closely allied to the last are the woolly monkeys, which have an equally well-developed prehensile tail, but better proportioned limbs, and a thick, woolly fur of a uniform gray or brownish color. They have well-formed fingers and thumbs, both on the hands and feet, and are rather deliberate in their motions, and exceedingly tame and affectionate in captivity. They are great eaters, and are usually very fat. They are found only in the far interior of the Amazon Valley, and, having a delicate constitution, seldom live long in Europe. These monkeys are not so fond of swinging themselves about by their tails as are the spider-monkeys, and offer more opportunities of observing how completely this organ takes the place of a fifth hand. When walking about a house, or on the deck of a ship, the partially curled tail is carried in an horizontal position on the ground, and the moment it touches anything it twists round it and brings it forward, when, if eatable, it is at once appropriated; and when fastened up the animal will obtain any food that may be out of reach of its hands with the greatest facility, picking up small bits of biscuit, nuts, etc., much as an elephant does with the tip of his trunk.

We now come to a group of monkeys whose prehensile tail is of a less perfect character, since it is covered with hair to the tip, and is of no use to pick up objects. It can, however, curl round a branch, and serves to steady the animal while sitting or feeding, but is never used

to hang and swing by, in the manner so common with the spider-monkeys and their allies. These are rather small-sized animals, with round heads and with moderately long tails. They are very active and intelligent, their limbs are not so long as in the preceding group, and, though they have five fingers on each hand and foot, the hands have weak and hardly opposable thumbs. Some species of these monkeys are often carried about by itinerant organ-men, and are taught to walk erect and perform many amusing tricks. They form the genus *Cebus* of naturalists.

The remainder of the American monkeys have non-prehensile tails, like those of the monkeys of the Eastern hemisphere; but they consist of several distinct groups, and differ very much in appearance and habits. First we have the Sakis, which have a bushy tail and usually very long and thick hair, something like that of a bear. Sometimes the tail is very short, appearing like a rounded tuft of hair; many of the species have fine bushy whiskers, which meet under the chin, and appear as if they had been dressed and trimmed by a barber, and the head is often covered with thick, curly hair, looking like a wig. Others, again, have the face quite red, and one has the head nearly bald—a most remarkable peculiarity among monkeys. This latter species was met with by Mr. Bates on the upper Amazon, and he describes the face as being of a vivid scarlet, the body clothed from neck to tail with very long, straight, and shining white hair, while the head was nearly bald, owing to the very short crop of thin, gray hairs. As a finish to their striking physiognomy, these monkeys have bushy whiskers, of a sandy color, meeting under the chin, and yellowish-gray eyes. The color of the face is so vivid that it looks as if covered with a thick coat of bright scarlet paint. These creatures are very delicate, and have never reached Europe alive, though several of the allied forms have lived some time in our Zoölogical Gardens.

An allied group consists of the elegant squirrel-monkeys, with long, straight, hairy tails, and often adorned with prettily variegated colors. They are usually small animals; some have the face marked with black and white, others have curious whiskers, and their nails are rather sharp and claw-like. They have large, round heads, and their fur is more glossy and smooth than in most other American monkeys, so that they more resemble some of the smaller monkeys of Africa. These little creatures are very active, running about the trees like squirrels, and feeding largely on insects as well as on fruit.

Closely allied to these are the small group of night-monkeys, which have large eyes, and a round face surrounded by a kind of ruff of whitish fur, so as to give it an owl-like appearance, whence they are sometimes called owl-faced monkeys. They are covered with soft, gray fur, like that of a rabbit, and sleep all day long, concealed in hollow trees. The face is also marked with white patches and stripes, giving it a rather carnivorous or cat-like aspect, which, perhaps, serves

as a protection, by causing the defenseless creature to be taken for an arboreal tiger-cat, or some such beast of prey.

This finishes the series of such of the American monkeys as have a larger number of teeth than those of the Old World. But there is another group, the Marmosets, which have the same number of teeth as Eastern monkeys, but differently distributed in the jaws, a premolar being substituted for a molar tooth. In other particulars they resemble the rest of the American monkeys. These are very small and delicate creatures, some having the body only seven inches long. The thumb of the hands is not opposable, and instead of nails they have sharp, compressed claws. These diminutive monkeys have long, non-prehensile tails, and they have a silky fur, often of varied and beautiful colors. Some are striped with gray and white, or are of rich brown or golden-brown tints, varied by having the head or shoulders white or black, while in many there are crests, frills, manes, or long ear-tufts, adding greatly to their variety and beauty. These little animals are timid and restless; their motions are more like those of a squirrel than a monkey. Their sharp claws enable them to run quickly along the branches, but they seldom leap from bough to bough, like the larger monkeys. They live on fruits and insects, but are much afraid of wasps, which they are said to recognize even in a picture. This completes our sketch of the American monkeys, and we see that, although they possess no such remarkable forms as the gorilla or the baboons, yet they exhibit a wonderful diversity of external characters, considering that all seem equally adapted to a purely arboreal life. In the howlers we have a specially developed voice-organ, which is altogether peculiar; in the spider-monkeys we find the adaptation to active motion among the topmost branches of the forest-trees carried to an extreme point of development; while the singular nocturnal monkeys, the active squirrel-monkeys, and the exquisite little marmosets, show how distinct are the forms under which the same general type may be exhibited, and in how many varied ways existence may be sustained under almost identical conditions.

LEMURS.—In the general term, monkeys, considered as equivalent to the order *Primates*, or the *Quadrumana* of naturalists, we have to include another sub-type, that of the lemurs. These animals are of a lower grade than the true monkeys, from which they differ in so many points of structure that they are considered to form a distinct sub-order, or, by some naturalists, even a separate order. They have usually a much larger head and more pointed muzzle than monkeys; they vary considerably in the number, form, and arrangement of the teeth; their thumbs are always well developed, but their fingers vary much in size and length; their tails are usually long, but several species have no tail whatever, and they are clothed with a more or less woolly fur, often prettily variegated with white and black. They inhabit the deep forests of Africa, Madagascar, and Southern Asia,

and are more sluggish in their movements than true monkeys, most of them being of nocturnal or crepuscular habits. They feed largely on insects, eating also fruits and the eggs or young of birds.

The most curious species are—the slow lemurs of South India, small tailless nocturnal animals, somewhat resembling sloths in appearance, and almost as deliberate in their movements, except when in the act of seizing their insect prey ; the tarsier, or specter-lemur, of the Malay Islands, a small long-tailed nocturnal lemur, remarkable for the curious development of the hind-feet, which have two of the toes very short and with sharp claws, while the others have nails, the third toe being exceedingly long and slender, though the thumb is very large, giving the feet a very irregular and *outré* appearance ; and, lastly, the aye-aye of Madagascar, the most remarkable of all. This animal has very large ears and a squirrel-like tail, with long, spreading hair. It has large curved incisor teeth, which add to its squirrel-like appearance and caused the early naturalists to class it among the rodents. But its most remarkable character is found in its fore-feet or hands, the fingers of which are all very long and armed with sharp, curved claws, but one of them, the second, is wonderfully slender, being not half the thickness of the others. This curious combination of characters shows that the aye-aye is a very specialized form—that is, one whose organization has been slowly modified to fit it for a peculiar mode of life. From information received from its native country, and from a profound study of its organization, Professor Owen believes that it is adapted for the one purpose of feeding on small, wood-boring insects. Its large feet and sharp claws enable it to cling firmly to the branches of trees in almost any position ; by means of its large, delicate ears it listens for the sound of the insect gnawing within the branch, and is thus able to fix its exact position ; with its powerful curved gnawing teeth it rapidly cuts away the bark and wood till it exposes the burrow of the insect, most probably the soft larva of some beetle, and then comes into play the extraordinary long wire-like finger, which enters the small cylindrical burrow, and with the sharp bent claw hooks out the grub. Here we have a most complex adaptation of different parts and organs all converging to one special end, that end being the same as is reached by a group of birds, the woodpeckers, in a different way ; and it is a most interesting fact that, although woodpeckers abound in all the great continents, and are especially common in the tropical forests of Asia, Africa, and America, they are quite absent from Madagascar. We may therefore consider that the aye-aye really occupies the same place in nature in the forests of this tropical island as do the woodpeckers in other parts of the world.

Distribution, Affinities, and Zoölogical Rank of Monkeys.—Having thus sketched an outline of the monkey-tribe as regards their more prominent external characters and habits, we must say a

few words on their general relations as a distinct order of mammalia. No other group, so extensive and so varied as this, is so exclusively tropical in its distribution, a circumstance no doubt due to the fact that monkeys depend so largely on fruit and insects for their subsistence. A very few species extend into the warmer parts of the temperate zones, their extreme limits in the northern hemisphere being Gibraltar, the western Himalayas at eleven thousand feet elevation, East Thibet, and Japan. In America they are found in Mexico, but do not appear to pass beyond the tropic. In the southern hemisphere they are limited by the extent of the forests in South Brazil, which reach about 30° south latitude. In the East, owing to their entire absence from Australia, they do not reach the tropic; but in Africa some baboons range to the southern extremity of the continent.

But this extreme restriction of the order to almost tropical lands is only recent. Directly we go back to the Pliocene period of geology, we find the remains of monkeys in France, and even in England. In the earlier Miocene several kinds, some of large size, lived in France, Germany, and Greece, all more or less closely allied to living forms of Asia and Africa. About the same period monkeys of the South American type inhabited the United States. In the remote Eocene period the same temperate lands were inhabited by lemurs in the East, and by curious animals believed to be intermediate between lemurs and marmosets in the West. We know from a variety of other evidence that throughout these vast periods a mild and almost sub-tropical climate extended over all Central Europe and parts of North America, while one of a temperate character prevailed as far north as the Arctic Circle. The monkey-tribe then enjoyed a far greater range over the earth, and perhaps filled a more important place in Nature than it does now. Its restriction to the comparatively narrow limits of the tropics is no doubt mainly due to the great alteration of climate which occurred at the close of the Tertiary period, but it may have been aided by the continuous development of varied forms of mammalian life better fitted for the contrasted seasons and deciduous vegetation of the north temperate regions. The more extensive area formerly inhabited by the monkey-tribe would have favored their development into a number of divergent forms, in distant regions and adapted to distinct modes of life. As these retreated southward and became concentrated in a more limited area, such as were able to maintain themselves became mingled together as we now find them, the ancient and lowly marmosets and lemurs subsisting side by side with the more recent and more highly developed howlers and anthropoid apes.

Throughout the long ages of the Tertiary period monkeys must have been very abundant and very varied, yet it is but rarely that their fossil remains are found. This, however, is not difficult to explain. The deposits in which mammalian remains most abound are

those formed in lakes or in caverns. In the former the bodies of large numbers of terrestrial animals were annually deposited, owing to their having been caught by floods in the tributary streams, swallowed up iu marginal bogs or quicksands, or drowned by the giving way of ice. Caverns were the haunts of hyenas, tigers, bears, and other beasts of prey, which dragged into them the bodies of their victims, and left many of their bones to become imbedded in stalagmite or in the muddy deposit left by floods, while herbivorous animals were often carried into them by these floods, or by falling down the swallow-holes which often open into caverns from above. But, owing to their arboreal habits, monkeys were to a great extent freed from all these dangers. Whether devoured by beasts or birds of prey, or dying a natural death, their bones would usually be left on dry land, where they would slowly decay under atmospheric influences. Only under very exceptional circumstances would they become imbedded in aqueous deposits ; and, instead of being surprised at their rarity, we should rather wonder that so many have been discovered in a fossil state.

Monkeys, as a whole, form a very isolated group, having no near relations to any other mammalia. This is undoubtedly an indication of great antiquity. The peculiar type which has since reached so high a development must have branched off the great mammalian stock at a very remote epoch, certainly far back in the Secondary period, since in the Eocene we find lemurs and lemurine monkeys already specialized. At this remoter period they were probably not separable from the insectivora, or (perhaps) from the ancestral marsupials. Even now we have one living form, the curious Galeopithecus, or flying lemur, which has only recently been separated from the lemurs, with which it was formerly united, to be classed as one of the insectivora ; and it is only among the opossums and some other marsupials that we again find hand-like feet with opposable thumbs, which are such a curious and constant feature of the monkey-tribe.

This relationship to the lowest of the mammalian tribes seems inconsistent with the place usually accorded to these animals at the head of the entire mammalian series, and opens up the question whether this is a real superiority or whether it depends merely on the obvious relationship to ourselves. If we could suppose a being gifted with high intelligence, but with a form totally unlike that of man, to have visited the earth before man existed in order to study the various forms of animal life that were found there, we can hardly think he would have placed the monkey-tribe so high as we do. He would observe that their whole organization was specially adapted to an arboreal life, and this specialization would be rather against their claiming the first rank among terrestrial creatures. Neither in size, nor strength, nor beauty, would they compare with many other forms, while in intelligence they would not surpass, even if they equaled, the horse or the beaver. The carnivora, as a whole, would certainly be

held to surpass them in the exquisite perfection of their physical structure, while the flexible trunk of the elephant, combined with his vast strength and admirable sagacity, would probably gain for him the first rank in the animal creation.

But if this would have been a true estimate, the mere fact that the ape is our nearest relation does not necessarily oblige us to come to any other conclusion. Man is undoubtedly the most perfect of all animals, but he is so solely in respect of characters in which he *differs* from all the monkey-tribe—the easily erect posture, the perfect freedom of the hands from all part in locomotion, the large size and complete opposability of the thumb, and the well-developed brain, which enables him fully to utilize these combined physical advantages. The monkeys have none of these, and without them the amount of resemblance they have to us is no advantage, and confers no rank. We are biased by the too exclusive consideration of the man-like apes. If these did not exist, the remaining monkeys could not be thereby deteriorated as to their organization or lowered in their zoölogical position; but it is doubtful if we should then class them so high as we now do. We might then dwell more on their resemblances to lower types—to rodents, to insectivora, and to marsupials, and should hardly rank the hideous baboon above the graceful leopard or stately stag. The true conclusion appears to be, that the combination of external characters and internal structure which exists in the monkeys is that which, when greatly improved, refined, and beautified, was best calculated to become the perfect instrument of the human intellect, and to aid in the development of man's higher nature; while, on the other hand, in the rude, inharmonious, and undeveloped state which it has reached in the quadrumana, it is by no means worthy of the highest place, or can be held to exhibit the most perfect development of existing animal life.—*Contemporary Review.*

THE DEVELOPMENT OF THE SENSES.

By ROBERT W. LOVETT.

IN the fifth century before Christ, Democritus declared that the senses of sight, hearing, smell, and taste were merely modifications of the sense of touch. Aristotle ridiculed his theory, and so, stamped with his disapproval, it lay untouched for two thousand years, until Telesius, an Italian of the sixteenth century, revived it.

Strange to say, all that modern science has accomplished in embryology and zoölogy tends to confirm this theory of Democritus, that these four senses are only specializations of the universal sense—the sense of touch. In the embryo of all animals the organs of these four senses first appear as infoldings of the outer germinal layer, the ecto-

derm, from which the outer skin also develops. At an early stage they are all simple pockets in the outer covering. If the history of the embryo is to be taken as the miniature of the history of the race—that is, if the individual in its development follows the same course that the race has followed, and it seems reasonable to suppose that this is the case—it is easy to see the importance of this evidence.

In the animal kingdom the sense of touch is universal; it is even found in those lowest animals, the protozoa, which are only masses of simple protoplasm. But, if this animal with its one sense is to become higher, there must be a division of labor ; there is too much work for one sense to do properly, and by a quantitative modification this primitive sense is to become qualitatively different in parts, and this qualitative difference is the difference which we notice between the sense of touch and the other senses of the higher animals; it has come about by an accumulation of the sense of touch.

The waves of air which fall on the body of this protozoan as heat are capable of a higher rendering, they will signify more than heat to the proper organ for perceiving them, they will give the sensations of light and colors. The simplest eyes are merely pigment-spots in the skin, they merely distinguish heat from cold and light from darkness ; but later, by the formation of a lens and sensitive membrane, the external world is revealed in all its variety.

The eye is first found in the sea-anemone, where it is merely one of these pigment-spots. But all that the most complete eye can give to us is a field of gradated colors. In itself this field of colors conveys no information to us. It must be explained before it can be of any practical use to us, and this necessary explanation can only be furnished by our sense of touch. That is, distance, magnitude, and shape are not directly perceived by the eye, but are suggested by certain objective gradations of color which have been associated with them in our past experience. Thus, sight appears as entirely dependent upon touch for its usefulness. This theory was first advanced by Bishop Berkeley in his famous "Essay toward a New Theory of Vision," and was afterward confirmed in a very wonderful way by some experiments made by Dr. Cheselden, of London. A young man had been blind from his birth on account of cataracts. These were removed by Dr. Cheselden, and he suddenly received his s'ght. At first he could perceive no such thing as distance or form. Only by repeatedly touching objects could he bring himself to realize that certain experiences of touch were always associated with certain gradations of color. Gradually he connected the sensations of sight with the sensations of touch, and in time became as insensible as we are to their true relation.

The ear first appears, in the jelly-fish, as a pocket in the outer skin. In this simple condition it serves as a general indicator of violent air-motion. But as the animal becomes higher there is a demand for a nicer perception of sound, and this pocket is closed and finally is pro-

vided with a complicated acoustic apparatus, in the same way that the eye is provided with a lens, which renders into terms of noise and music those air-waves which to the rest of the skin are imperceptible.

But a sound conveys no more information in itself than does the field of colors presented by the eye; only when we can tell from what it comes, and what consequences have been connected with it in our past experience, does it have any practical meaning to us. And, again, this explanation can only be furnished by our sense of touch, or by our sense of sight, which, as we have seen, is entirely dependent upon our sense of touch.

The senses of smell and taste should properly be resolved into one sense, for they are probably only late modifications of the same property of the mucous membrane lining the mouth and nose. This membrane is only an invading growth of the skin surrounding the mouth, so, morphologically, this sense is the same as the two just examined. The sense of smell is undoubtedly present in some insects, as, for instance, in the burying beetles, and may perhaps be found lower.

In man this double sense is undoubtedly retrogressive, and probably reaches its highest development in some of the lower mammalia. With us it is at best only a source of transitory pleasure, and seems in no way to contribute to our higher mental development.

But the senses of sight and hearing are very different in this respect. If Darwin is right, they have played a most important part in the evolution of the past as the instruments of sexual selection. And, in the future development of our race, it seems as if their perfection would be reached only with the perfection of the human mind. For if the impulse to development is given from without by the environment, these organs must be continually improved so as to perceive the nicer and nicer distinctions in the environment which will be the means of elevating the mind. If the impulse to development is given from within the mind, these sense-organs must be developed more highly in order to provide the enlarging mind with the continually nicer perception which it will require.

Man's mind develops, not his body. With the exception of these two sense-organs, his body has been nearly stationary for thousands of years, but these two organs respond to comparatively little change. The ear of the savage differs from the ear of the civilized man more than the two men differ in any other respect.

Touch, smell, and taste seem as complete as they need be for any conceivable human being, but that the eye is yet incomplete is very strikingly shown by the so-called actinic rays of the solar spectrum. In this spectrum there are rays beyond the violet which have an action on certain chemical substances much like the action of the blue and violet rays. But to the human eye these rays are absolutely invisible. The perception of this unknown color seems but a short step in the development of the eye.

But how different from the others, both in character and history, is the sense of touch! Having with them a common origin, like them it is resident in the outer skin, but it is active alike all over the body; the touch of the finger-tips may be more delicate than that of the palms, but it is only a quantitative difference. The sense of touch is the fundamental sense. All the other senses have to render their data into its terms before they can be understood by the mind. Animals can live without sight, hearing, taste, or smell, but the presence of the sense of touch seems a necessary condition of animal existence. The other senses are means of self-preservation; the sense of touch is the manifestation of an animal's existence.

The senses, then, all originate from the outer covering; this covering has from the beginning a special sensation from the resistance to external pressure; this property it retains throughout the animal kingdom. The other sense-organs appear as specialized parts of this universal sense-organ; morphologically they are only parts of the skin, rendered more sensitive than the normal skin.

All the evidence seems to point one way, to the conclusion that the other senses are all modifications of the sense of touch. That such is probably the fact seems to be generally admitted. What I have tried to show is our ground for that conclusion, and that what was with Democritus a random speculation is with us fast assuming the nature of a scientific truth.

THE STEREOSCOPE: ITS HISTORY.*

BY W. LE CONTE STEVENS.

I.

THAT a near object of small dimensions presents an aspect slightly different to each one of a pair of eyes directed upon it, has been known for more than two thousand years; but no application of this knowledge was ever made until some time after the beginning of the present century. The analysis of binocular vision is one of the products of modern investigation, and the stereoscope is its direct outcome. That vision with two eyes is greatly preferable to what the ancients accorded to Polyphemus is fully appreciated by every one who possesses a pair of healthy visual organs and a stereoscope, but who at any time has been so unfortunate as to suffer a temporary injury that reduces him for a few days to the condition of the classic monocular giant. Familiar as he may be with the truth that the perspective effect of a fine painting is better appreciated when one eye is closed,

* Expanded from an address before the Photographic Section of the American Institute, delivered March 7, 1882.

he is never willing to keep it thus inactive any longer than necessary; and, if such a hint is gently suggested, he is prompt to answer it by some prosaic contrast between the artist's clever illusion and the necessities of life in a wide-awake world. Lord Bacon says: "We see more exquisitely with one eye than with both, because the vital spirits thus unite themselves the more, and become the stronger; for we may find by looking in a glass whilst we shut one eye that the pupil of the other dilates." But even the cogent logic of Lord Bacon would scarcely reconcile many of us to the adoption of strictly Cyclopean customs in the enjoyment of vision.

In response to the question, "What is the use of having two eyes?" the answer has been given, "To have one left if the other is hurt." Much as we may admire the sagacious foresight of this youthful physiologist, it will not be found sufficient to rest contented with his ultimatum. He had evidently not tried his skill to find how unexpectedly he would miss the inkstand while endeavoring to dip his pen into it at arm's length, with one eye closed. He had not thought of holding his finger a few inches in front of his face to find what part of the wall it would hide from each eye in succession, or how differently it would look when regarded from those two points of view separately, how much thicker it would appear when both eyes were open, how readily he could examine three sides of it at once, how much more definitely he could judge its distance, in a word how much more comprehensive was the information given by two eyes if used at the same moment. Assuming that he knows exactly how to account for the inversion of the retinal image and the erect appearance of the object there pictured, how our visual perceptions are only signs of what we momentarily feel on the retina, signs that generally represent the realities with a fair degree of accuracy, but may sometimes represent almost anything else on demand, how, if the eyes be healthy, we have no consciousness of possessing any retina at all, but instantly and unconsciously refer every retinal sensation to some external body whose existence we are obliged to assume, unless there be special arguments to convince us to the contrary—granting all this, our young physiologist has not thought of inquiring how it is that, although two retinal images are produced, we see but a single object, and this despite the fact that, like photographs of the same body simultaneously taken from different stand-points, these two images are necessarily dissimilar.

This question, and especially its latter part, is much more easily asked than answered with fullness, clearness, and certainty. There is no antecedent reason why two separate retinal images should not produce the impression of two separate bodies. That they may do so must have come within the experience of every one. A few glasses of champagne are often enough to convince the most skeptical. Without resorting, however, to agencies that produce involuntary though temporary loss of muscular control of the eyes, it is only necessary to

gaze at any clearly defined object for a few moments, and press upon the eyeball near the outer corner of the opening between the lids—double vision is instantly attained. The condition thus induced is unnatural, and the effect is unnatural vision. Our modes of interpreting nerve-impressions, like our modes of mental and bodily action in other respects, are the results partly of individual experience and partly of inheritance through countless generations. If a blow is received upon the right cheek, whether it be from a solid body or from a wave in the medium in which we are immersed, experience at once suggests the direction from which it came. If through many generations every individual were continually receiving gentle blows on the center of the right cheek through all the moments of waking existence, and the accurate perception of these were conducive to his welfare, then on physiological principles it seems in the highest degree probable that the judgment of direction by the cheek might become as habitual and unerring as is our judgment of direction by the eye. By a liberal construction of language we might be said to that extent to see with the cheek; and the man who is blessed with the healthiest, best-trained,

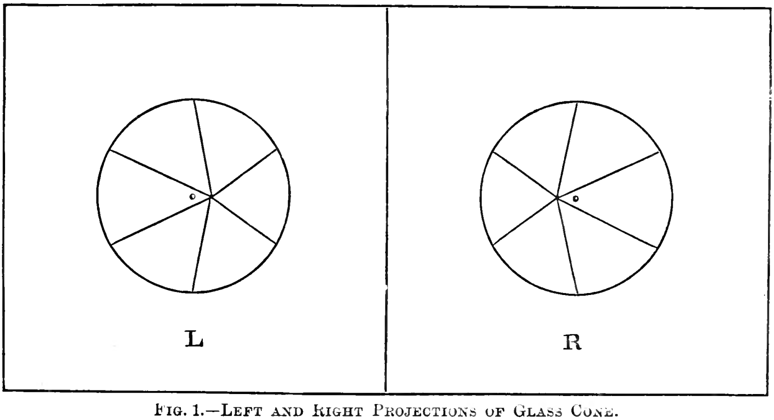


FIG. 1.—LEFT AND RIGHT PROJECTIONS OF GLASS CONE.

and most vigorous cheek, aside from other qualities, would be most apt to win in the struggle for existence. If, then, in normal vision each of two eyes receives impressions due to wave-impulses from the same external object, the position of this is referred to the same external place in accordance with the association that experience, individual and ancestral, instantly arouses in response to the sensation felt on each separate retina. If, therefore, every person were blessed with such optic luxuriance as is attributed to the fabled Argus, there is no reason to suppose that, if each eye be healthy and ordinarily controllable, he would have anything else than single vision, unless the necessities imposed in the struggle for success made it advantageous to acquire the power of dissociating the action of the muscles of these eyes, and thus making use of voluntary multiple vision.

In an essay published many years ago, Carlyle dwelt, in a manner characteristically his own, upon the unconsciousness that is a mark of health in the human body. The dyspeptic man knows full well that he has a stomach, but the eupeptic child has no conception of the existence of such an organ, however vivid may be its ideas of fairies, ogres, and dragons. In like manner the retina is an abstraction for him who has good binocular vision and but little book-lore. With a single eye he sees many objects at the same time, and judges their different positions; the only idea aroused is about the objects themselves, and not about the retinal impressions from them. If both eyes be directed to the same distant point, there is still the same consciousness of a single external thing, and not of two eyes. By slowly crossing the two visual lines for the purpose of comprehensively scanning the root of one's own nose, which is the nearest object that can be regarded with entire convenience, if both eyes are of equal power, the visual impression is found to be that two noses are approaching each other, and closing up the brightest part of the field of view in front. Between them is left a narrow heart-shaped window, with dimly transparent nasal shutters. The outlines of these are most easily discerned by momentarily closing each eye alternately, while the convergence of visual lines is vigorously retained, and then opening both and depending on indirect vision. If there is any consciousness of an eye at all, it is referred to the sensation of strain in the muscles that seem to be pulling the shutters together, and not to any retina receiving pictures of them. There is, indeed, the consciousness of looking out of the window from a single stand-point, but not from two eyes. The subjective impression is that the two points of view are identified into a single eye, whose position is central and constitutes the point of origin from which all our estimates of direction and distance are made. Keeping the nasal window as small as possible by cross-vision, and endeavoring to test the real singleness of the double-phantom nose by gently putting the finger upon it from in front, it is easy additionally to convince one's self that

"... things are not what they seem."

Two fingers will be seen approaching from different directions. If it should occur to the indignant observer that these may be utilized in putting an end to his nasal redundancy by closing up the window, they will steadily converge and strike together upon the root of the nose, almost exactly where he had been supposing his point of view to be. The window at the next moment, instead of being closed, will be opened wide, and, on resting the tired muscles of his eyes, he will find that the phantom-noses have leaped to the two sides, the position of each being indicated by the faithful ghosts of the finger. The experiment is a little surprising at first, and the specters are very shadowy, but a literally close search will be quite sure to reveal them by indirect vision.

Subjectively, therefore, our condition is not so very different from that of the famous Cyclops. We have the advantage of being able to see double, by adjusting conditions properly; but, if sensation is to be trusted, the object is duplicated while the eye is single, although by other means we learn that the object remains single, and is only viewed from two different stand-points at the same moment, while the sepa-

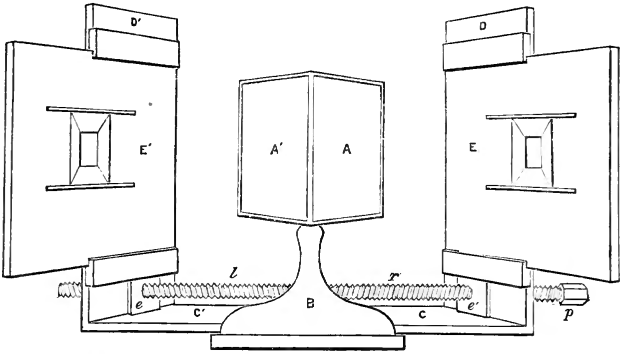


FIG. 2.—WHEATSTONE'S STEREOSCOPE. (Front View.)

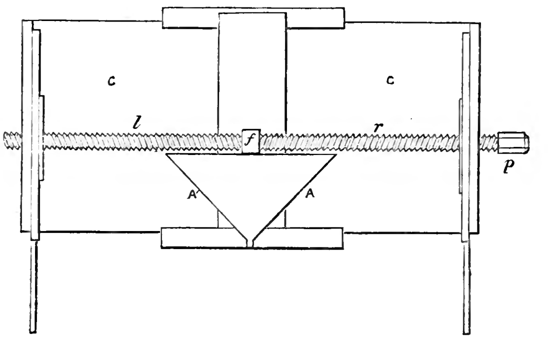


FIG. 3.—WHEATSTONE'S STEREOSCOPE. (Ground Plan.)

rate lines of direction for the two eyes meet elsewhere. By appropriate muscular training the eyes may be directed, each slightly outward, so that these lines meet behind the observer's head while the object, apparently duplicated, is seen still in front. The recognition of the subjective fusion of the two eyes into a Cyclopean, or central binocular eye, is a fundamental prerequisite for the explanation of vision in the stereoscope. In consequence of this, if two similar pictures are placed close in front of the eyes, the distance between their centers being equal to the distance between the pupils, they at once appear to coalesce into a single picture. In this way an objective existence may appear to be given to the binocular eye by approaching a mirror until the nose touches the glass, and avoiding the convergence of visual lines that would otherwise be natural. A narrow face is seen, possess-

ing but a single eye, that looks into the very depths of the observer's Cyclopean eye.

The conception of this subjective union as the product of the experience of the race in interpreting sensations, and the consequent necessity of distinguishing between realities and their visual representations, seems never to have been appreciated until long after the invention of instruments for use in the analysis of vision. Much confusion has resulted from the attempt to explain what are really subjective results of retinal sensation by the application of geometric principles, irrespective of the illusive union of the two eyes when employed together. In 1604 Kepler stated that the distance between the eyes constituted a base-line, which we employ for measuring the distance of objects by a species of visual triangulation. This idea was subsequently greatly elaborated by Sir David Brewster and others; and in most, if not all, of our text-books of physics to-day it is applied in a very familiar diagram to explain the principle of the stereoscope. On this theory the apparent position of every point in the stereoscopic field of view is determined by the meeting of separate visual lines, which converge in front. An obvious consequence is that this localization should become impossible if the visual lines become parallel or divergent. But, in truth, there can be no perception of locality by this method. If the eyes are subjectively united, the visual lines become subjectively united along with them; if, indeed, such language is at all applicable to lines that are mere abstractions. In its application to stereoscopic vision, therefore, the diagram is worthless; for such vision is much easier to most persons when the visual lines are parallel, or very slightly divergent, than when they are strongly convergent, and in no case can there be any recognition of intersection between lines which, if subjectively perceived at all, would be coincident throughout their whole extent.

The error just mentioned has undoubtedly sprung from the assumption that stereoscopic vision is always perfectly normal. If this be so, it should be as painless as the reading of this page, even when continued for hours in succession. Every one who has tried the experiment with an ordinary stereoscope, and a large, miscellaneous collection of stereographs, knows how wearying it is, and how in some cases distinct vision is found impossible. To indicate the real differences between normal vision and that which is attained in most stereoscopes, it will be necessary first to study the development of this instrument.

The duality of human vision of near objects, and the consequent dissimilarity of retinal pictures in the separate eyes, was apprehended and more or less vaguely discussed by Euclid (B. C. 300), Galen (A. D. 200), Baptista Porta (1593), Leonardo da Vinci (1584), Aguilonius (1613), and by Smith, Harris, and Porterfield during the eighteenth century. No practical results were wrought, however, until 1838, when Sir Charles Wheatstone read before the Royal Society his

now classic paper on the "Physiology of Vision." Let the reader imagine, or actually put on the page before him, some small solid body, such as a cone, with a few lines drawn from its vertex to the base. If it be of glass, so much the better; an ink-dot can then be marked at the center of the base, and the lines scratched upon the sides can easily be blackened. Close the left eye; the cone appears to the right eye like Fig. 1, *R*. Without moving the head, look with the left eye alone; the appearance is like Fig. 1, *L*. If each eye were in succession transformed for a moment into an electric light, the shadows projected upon the paper would be those given in the figure, but with a common base. Opening both eyes, the perception of the height of the cone is far more distinct than when either is closed. Let us now quote Wheatstone's own words: "It being thus established that the mind perceives an object of three dimensions by means of the two dissimilar pictures projected by it on the two retinæ, the following question occurs: What would be the visual effect of simultaneously presenting to each eye, instead of the object itself, its projection on a plane surface as it appears to that eye? To pursue this inquiry, it is necessary that means should be contrived to make the two pictures, which must necessarily occupy different places, fall on similar parts of both retinæ. Under the ordinary circumstances of vision, the object is seen at the concourse of the optic axes (visual lines*), and its images consequently are projected on similar parts of the two retinæ; but it is also evident that two exactly similar objects may be made to fall on similar parts of the two retinæ, if they are placed one in the direction of each optic axis, at equal distances before or beyond their intersection."

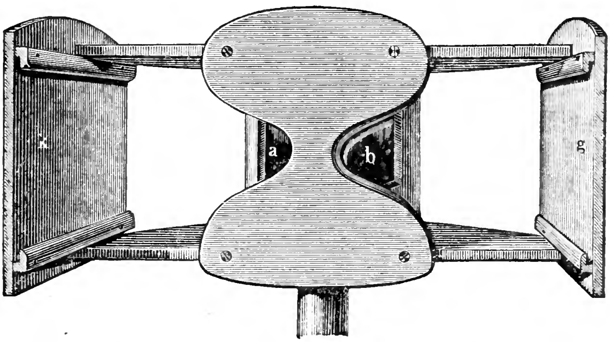


Fig. 4.—Wheatstone's Stereoscope (Perspective View), 1838.

To follow out to the letter the instructions suggested in Wheatstone's last sentence, transfer Fig. 1 to glass. This can be easily done. Upon an oblong plate of window-glass put a few drops of clear varnish; let it spread thinly over the surface and become thoroughly dry.

* In Wheatstone's time the visual lines were supposed to be optic axes. That this is not quite so has since been proved by Helmholtz.

Copy the picture, of exact size, by scratching through the varnish, and then blacken the lines with ink. Hold the transparent plate at the distance of a foot from your eyes, and through it look at a point about five feet away. Very little motion of the plate is needed to get this point exactly aligned with each of the dots within the circles by looking with each eye in succession. Look at the point now with both eyes, and you will see, suspended in the air, probably just beyond the plate, apparently a solid cone of glass pointing toward you, the very *fac-simile* of our glass cone from which the pictures were taken.

Copy the picture also on paper or card-board, of exact size, but with the part marked *R* transferred to the left, and that marked *L* to the right. Hold up the point of a pencil about half-way between your eyes and the card. In a moment the proper position is found, where it is aligned with *R* for the right eye and with *L* for the left. Open both eyes and converge them upon the pencil-point. A little cone pointing toward you is suspended in the air just beyond the pencil, which may now be withdrawn. Move your head from side to side: the cone moves with you. It is brilliantly lustrous, sharp in outline, and much smaller than that previously seen. Two companion circles, one on each side, are left behind on the card, and are larger than the base of the suspended cone, but a little smaller than the circles originally were. Their appearance is due to images of *R* and *L* which fall upon retinal parts that in normal vision could not be simultaneously impressed by

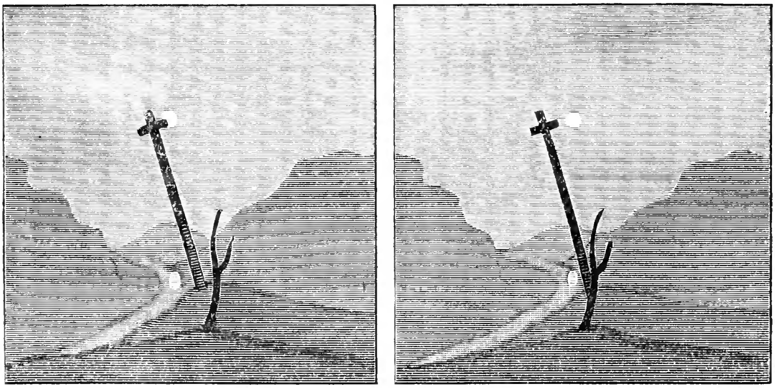


Fig. 5.—The First Landscape Stereograph.

an external single body. The sensations produced by them are hence not suggestive of singleness, and each is therefore referred separately outward in the direction from which the rays producing them have come. Such side-images are perceived also when the glass plate is employed. Try the same experiment now with the picture on the page; the miniature cone leaps off the paper into the air, but this time it is hollow, for its vertex is pointed to the place from which it seems to have sprung.

These experiments are delightfully surprising when successfully accomplished for the first time. They are well worth the trifling preliminary trouble which they entail. But even this can be in great measure avoided by having a photograph of the picture taken on glass. If you will previously approach the polite photographer in your most charmingly courteous and irresistible style, enable him to perceive the glittering phantom cone reversed in mid-air, invite him to grasp it and give to this "airy nothing a local habitation and a name," and convince him that, if not illusive, it is even more elusive than the merry sunbeam which his camera alone can catch in all its beauty, he will at once be lost in admiration of your magic skill and singular sagacity, and instantly find it impossible to avoid preparing the wonder-working photograph on glass. This he will smilingly present to you in the most enthusiastic and complimentary manner, with evident gratitude for the favor you have bestowed, and the good taste you have exhibited in selecting him as the recipient of your discriminating and exclusive confidence.

The presence of the uncombined images at the sides of the binocular picture, as it stands out in solid relief, is apt to be confusing, because their effect is partially to distract the attention. In Wheatstone's first experiments, he avoided them by looking through tubes, or into a box. In any case, the methods of stereoscopy just described, although by far the most useful in studying the principles of binocular vision, are not usually acquired until after a few trials. When they are once mastered, it becomes easy to discard pencils and other points of fixation, and the voluntary muscular control of the eyes is sufficient for all cases. Wheatstone gave to the world a new revelation in both the science and the art of perspective, when, in 1838, he devised his reflecting stereoscope for the purpose of removing the difficulties involved in stereoscopy by direct vision. Figs. 2 and 3 are exact reproductions of his drawings, representing the front view and ground-plan of his original stereoscope; and, in describing them, we can not do better than again to give his own words: "A A′ are two plane mirrors, about four inches square, inserted in frames, and so adjusted that their backs form an angle of 90° with each other; these mirrors are fixed by their common edge against an upright, B, or against the middle line of a vertical board, cut away in such manner as to allow the eyes to be placed before the two mirrors. C C′ are two sliding boards, to which are attached the upright boards D D′, which may thus be removed to different distances from the mirrors. To facilitate this adjustment I employ a right- and a left-handed wooden screw, *r l*; the two ends of this compound-screw pass through the nuts *e e′*, which are fixed to the lower parts of the upright boards D D′, so that, by turning the screw-pin *p* one way, the two boards will approach, and, by turning it the other way, they will recede from each other; one always preserving the same distance as the other from the

middle line *f*. E E′ are panels, to which the pictures are fixed in such a manner that their corresponding horizontal lines shall be on the same level; these panels are capable of sliding backward and forward in grooves on the upright boards, D D′. The observer must place his eyes as near as possible to the mirrors, the right eye before the right-hand mirror, and the left eye before the left-hand mirror; and he must move the sliding-panels E E′ to or from him, until the two reflected images coincide at the intersection of the optic axes, and form an image of the same apparent magnitude as each of the component pictures."

In using this stereoscope, of which a perspective view is given in Fig. 4, the two conjugate pictures must be on separate cards, but may be much larger than those which are now so extensively used with more modern instruments. The arrangement is obviously such that no side-images can be perceived, since it is impossible for either eye to receive more than one image, and this is reflected from the oblique mirror directly in front. As an instrument it is unwieldy and inconvenient in comparison with those to which we are accustomed; but

Fig. 6.—The Binocular Camera.

with it the great secret of binocular vision was brought into open daylight. Wheatstone had the genius to find out how the door was to be unlocked, and it was left for others to devise the special forms that would be employed in making most acceptable to the world the treasure which he had found. His predecessors had more or less distinct conceptions of an hypothetical treasure, just as something was known about the nature of steam before the low-pressure engine was invented,

and about sound-waves before the telephone came into existence. To him distinctly belongs the credit of objectively demonstrating the essential features of binocular vision, with the first instrument actually constructed in accordance with principles which possibly others might have applied, if they had possessed equal clearness of conception and fertility of invention. So slight was the general appreciation of the fact that the two retinal images in binocular vision are dissimilar, that Wheatstone made this discovery independently, and then added the application which others had failed to make, but without the knowledge that any one had preceded him in even forming the conception. The originality of his discovery is not affected by the unemphatic statements afterward found to have been recorded by those who preceded him in thought but not in act.

One of these predecessors was Mr. James Elliot, of Edinburgh, who, "previous to or during the year 1834, had resolved to construct an instrument for uniting two dissimilar pictures." By delay he lost the golden opportunity, which, without envy or knowledge of his existence, was snatched away from him by Wheatstone. Not until 1839 did Elliot construct the instrument which he had contemplated. It was simply a wooden box, open at the extremities, so that a pair of conjugate pictures on glass could be placed at one end, and all light except that which was transmitted through them could be excluded from the eyes placed at the other end. He was not aware of Wheatstone's invention, which indeed did not become generally known for a

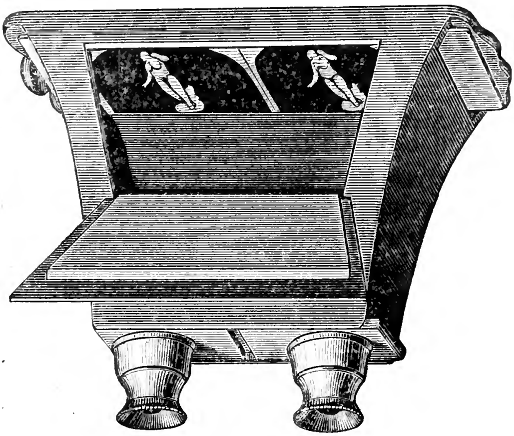


FIG. 7.—BREWSTER'S STEREOSCOPE, 1849.

number of years after its completion, because not adapted for general use, and because no other means than free-hand drawing existed for the accurate preparation of the conjugate pictures. Those employed by Wheatstone were outlines of various geometric solids. Elliot's first stereograph was a landscape, represented in Fig. 5, which is a

little smaller than that constructed by him. In the background of each picture is the moon, the stereographic interval between them being two and a half inches, which is about the average distance between the pupils of a pair of eyes. Next comes a cross, and in the foreground is the withered branch of a tree. In the picture on the right it is seen that the branch is nearly aligned with the cross, which is projected against the sky on one side of the moon; in that on the left one limb of the cross is projected against the moon, while the branch is wholly on the right of both. If the reader will place one edge of a card on the line between the two pictures, while the other edge touches his nose and forehead, he will perceive but a single picture, in which the branch, cross, and moon are successively farther away, the two former standing out in clear relief. By a little attention, moreover, he will see two phantom-cards, one on each side of the combined picture, and between the two his Cyclopean eye is regarding the landscape before him.

At the exhibition of Wheatstone's reflecting stereoscope, and the reading of his paper before the British Association at Newcastle, in August, 1838, one of the most interested auditors present was Sir David Brewster, who remarked on its important bearing upon the

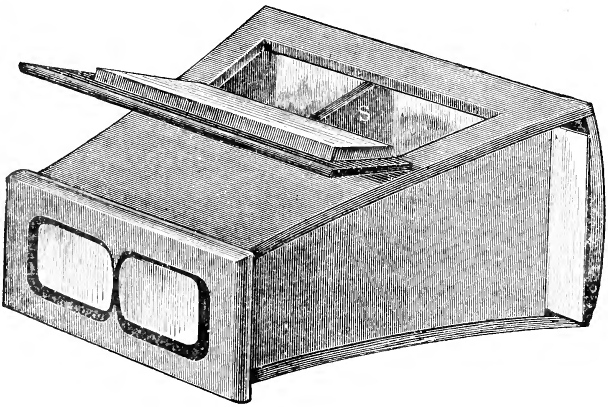


Fig. 8.—Modified Brewster Stereoscope.

theory of single vision to which he himself had given much attention. In his subsequent investigations he devised two important instruments which, with others of less value, were described in papers published in 1849. These were the binocular camera and the lenticular stereoscope. During the following year they were exhibited in Paris; and here it was that stereoscopy first became the delight of the people, after having been confined for a dozen years to the laboratory of the physicist.

The binocular camera needs but little description. Every one is familiar with the instrument, first devised in its simplest form by Bap-

tista Porta, as ordinarily employed by the modern photographer. It consists now of a dark chamber, into which light from the object to be pictured is converged with a combination of carefully corrected achromatic lenses upon a prepared plate whose distance can be readily adjusted. If provided with two such combinations a few inches apart (Fig. 6), so that two pictures of the same object can be simultaneously taken, thus from slightly different standpoints, it becomes the instrument on whose co-existence depends the value of the stereoscope. Without it the preparation of the stereograph would be practically impossible in many cases, for a living object, and even many inanimate objects, such as clouds, may move during the interval consumed in changing the position of the single camera and taking the two pictures successively. In the absence of photography dissimilar pictures must be made with the brush or pencil; and, aside from the labor thus imposed, few artists can compete with the sunbeam where perfect accuracy in every detail is required. Without the stereoscope, on the other hand, there would be little or no *raison d'être* for the binocular camera. Photography can scarcely be said to have had an existence before the publication, in 1839, of the labors of Talbot and Daguerre; and until Archer discovered, in 1851, that collodion could be employed as a vehicle for silver salts, the art was incapable of very wide or successful application for stereoscopic purposes. This epoch in photography, indeed, came after Brewster's double camera had been devised. The latter was itself the timely and natural outcome of the development of this art of sun-drawing, in conjunction with Brewster's invention of a far more convenient form of stereoscope than that employed by his distinguished contemporary. Wheatstone could hardly have entertained any idea of utilizing the evanescent images in silver nitrate obtained prior to 1802 by Wedgwood and Davy, or even those secured in 1814 by the elder Niepce on bituminized plates, which, indeed, were more permanent, but still far from satisfactory. Scarcely a year elapsed after Wheatstone's invention before the first photograph ever obtained from the human face was successfully taken by the leader in photography on our own side of the Atlantic, Dr. John W. Draper; but the art was not yet enough developed, even in such

FIG. 9.—ARRANGEMENT OF SEMI-LENSES.

hands, to suggest the application for stereoscopic purposes which was afterward so happily made by Brewster. To this physicist, therefore, we must credit the invention of the means by which stereoscopy was made to become co-extensive with photography.

The only difficulty in viewing a stereograph, as we have seen, consists in giving the proper direction to the eyes, which, in spite of the

efforts of the untrained observer, will generally converge to a single point of fixation. Brewster's mode of preventing this was, like Elliot's, to cause each of the two pictures to be viewed at the bottom of a box, through which light was transmitted. His stereoscope is shown in Fig. 7, which has been taken from an instrument brought to New York in 1850, and much prized by its owner as the first stereoscope ever seen in America. The box is of mahogany, and provided with a lid which can be raised so that an opaque card also may be viewed, if desired, by reflected light admitted from above. The bottom is made of roughened glass so as to diffuse the light that is transmitted, in case a photograph on glass is employed. In either case, the picture can slide easily in and out. To secure the natural convergence of visual lines, a condition which Brewster thought indispensable, a pair of semi-lenses were inclosed in brass tubes at the top of the box. These tubes could be drawn slightly out, like those of an opera-glass, and one was capable of slight lateral motion, being fixed upon a sliding plate of wood as shown in the drawing. They could thus be adapted to different pairs of eyes. They served the double purpose of holding the semi-lenses, with edges toward each other, at the most convenient dis-

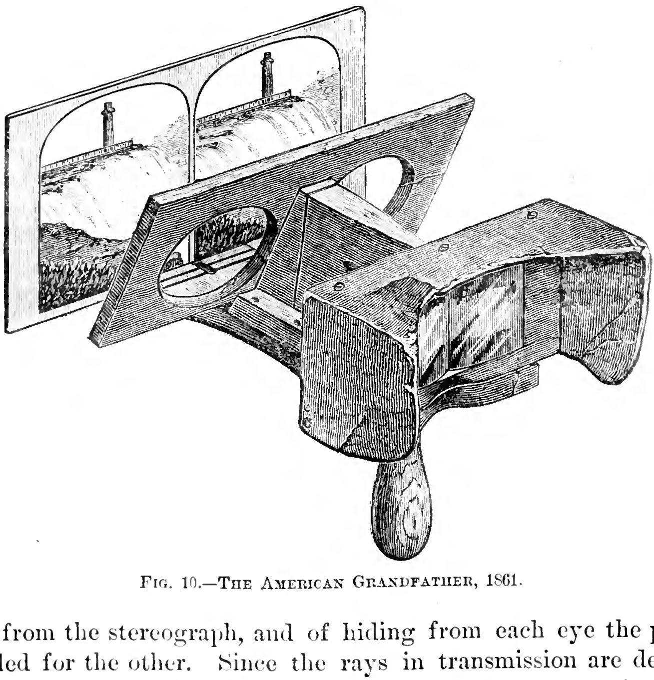


Fig. 10.—The American Grandfather, 1861.

tance from the stereograph, and of hiding from each eye the picture intended for the other. Since the rays in transmission are deviated toward the thicker part of the glass, it is possible without discomfort to use pictures on which the stereographic interval exceeds that between the observer's pupils. On ordinary stereographs, however, three inches is the usual limit. Another office performed by the semi-lenses

is that of magnifying the pictures as they are binocularly viewed. It was indeed a happy thought that produced such a combination of admirable features.

Much space could be occupied in describing the many forms of stereoscope that have been devised since that of Brewster was first put forth. They have all been applications of the principles already explained in connection with the reflecting and refracting instruments, devised in 1838 and 1849. That of Helmholtz is probably the best in Europe. In this each tube extends into the box, and is provided with a pair of accurately centred plano-convex lenses, which greatly magnify the pictures. It is indeed simply a pair of telescope eye-pieces, each of which is screwed into a plate to which lateral motion, for the purpose of adjustment, may be given with a screw, lever, and spring. To avoid the necessity of optic divergence, the stereograph must be comparatively small. Such an instrument is necessarily quite costly. The form most widely employed in Europe is that shown in Fig. 8, in which the box is divided by a partition (*s*), which does not extend so far as to prevent ready motion of the slide. The tubes are discarded and the semi-lenses are permanently fixed, edge to edge (Fig. 9), into the wood at the smaller end. This is objectionable, because no adjustment is possible for either the distance of the card or the width between the eyes.

Twenty years ago the stereoscope just described was the only one extensively used in America. At present it is hard to find, because totally displaced by another instrument, the device of a modest American whose name seems to be but little associated in the popular mind

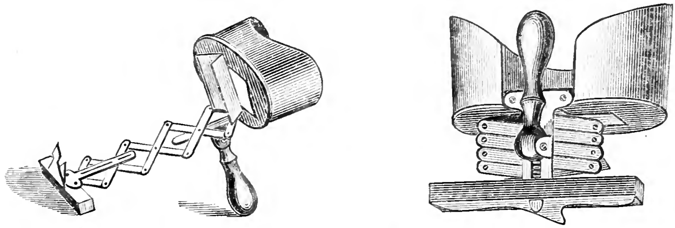


FIG. 11.—ACCOMMODATING GRANDCHILDREN, 1882.

with his own invention. This fact would be inexplicable were it not that he has made so many thousands of readers happy by his writings on literary topics that they think of him only as the poet, the professor, the genial "autocrat of the breakfast-table," whose delicate humor and warm human sympathy have so often caused smiles and tears to mingle together, that they forget him as the physiologist, who finds use for other instruments besides his mirth-provoking pen. There are few who think of him as an inventor, when they use the convenient and compact stereoscopes that have been multiplied in tens of thousands, until now no home is too humble, no father too poor, to delight

his little ones with phantom scenes of beauty, brought by the sunbeam and the stereoscope from places that their eyes will never behold. The writer will not be deemed blameworthy in transcribing, from a letter that was not intended for the public, a few lines which the author has consented to let him give. Dr. Holmes says: "It appeared to me that the box stereoscopes were cumbrous and awkward affairs. I had one of Smith and Beck's, and one or more of other patterns, but I did not like them; and so one day I cut out a piece of wood in some such shape as this (Fig. 10), the lines representing slots in which the stereograph was to be placed, stuck an awl in for a handle, and there was my stereoscope. . . . I have forgotten to mention the hood, which I made of pasteboard cut to fit. Other open instruments, and many closed ones, have been made, but most of them have been awkward, expensive, and sometimes *gimcracky*, whereas I think mine may be called simple, strong, cheap, handy."

No better compendium of good qualities can be expressed than is comprised in this brief list of four words. The figure is taken directly from "the original great-grandfather pattern," as the inventor has pleasantly called it, the "real Adam" of hand-stereoscopes, that was born—or developed—in 1861, delighted the human beings who lived in that remote day, and has been sleeping these many years. Compelled now to show itself, like Rip Van Winkle, it is perhaps a little stiff; and in style it is a trifle blunt, in comparison with its polished and accommodating great-grandchildren of the present day (Fig. 11), that fold up and pocket themselves out of sight; but nevertheless its character is that of a straightforward, clear-headed old ancestor, that looks forth honestly from under that somber hood.

To produce the illusion of viewing an actual sunlit scene, Dr. Holmes placed between the stereograph and the semi-lenses an oblique wooden plate, in which were a pair of elliptic openings, so that the effect was that of looking through a circular window. The front was covered with gilt paper from which a golden light was reflected upon the picture. As an appropriate name he selected that of "The Claude Lorraine Stereoscope."

The inventor offered his device gratuitously to manufacturers in New York and Philadelphia, but their refusal was as courteous as was consistent with firm opposition. He did not assume the trouble to secure it by patent, as he "did not care to make money by so obvious and simple a contrivance." A few of these stereoscopes were at last constructed by Mr. Joseph L. Bates, of Boston; and the demand rapidly grew so that now but few of any other make are to be found in the United States. Improvements, indeed, have been added, but not of such kind as to diminish the cost; one of these, introduced by Mr. Bates, was the substitution of a sliding cross-bar for the series of fixed slots. The "Claude Lorraine" effect may be easily obtained with any ordinary stereoscope, by the use of an extra cross-bar, on which the

gilt window-plate is hinged ; it may thus be adjusted to any position and inclined at will according to the direction from which the light comes.

A simple and moderately satisfactory stereoscope may be improvised by unscrewing the concave eye-pieces from an ordinary opera-glass, and looking through it at the stereograph, which must be held about six inches from the centers of the object-glasses and parallel to the line connecting these. Vision by this method, however, is very uncomfortable if the stereograph be large. The instrument is a crude Helmholtz stereoscope, but it needs adjusting-screws at both ends of each tube to make it entirely satisfactory. The only objection to Dr. Holmes's instrument is the absence of adjustment ; but, despite this defect, it is deservedly used everywhere in our country. Quietly and unselfishly he has done far more for the stereoscope in America than has ever been credited him by those who enjoy the fruits of his spontaneous and unpaid ingenuity.

MEASUREMENTS OF MEN.

By FRANCIS GALTON, F. R. S.

WHEN shall we have anthropometric laboratories, where a man may from time to time get himself and his children weighed, measured, and rightly photographed, and have each of their bodily faculties tested, by the best methods known to modern science? In the January number of this "Review" I endeavored to show the advantages of photographic chronicles maintained from childhood to age, and how they should be made and preserved ; in the present memoir I propose to briefly speak upon the anthropometric and medical facts that might properly be recorded by the side of the photographs in the family records to which I there referred. I shall endeavor to define the scope of what may be effected in this direction, partly by accurate apparatus now extant, and partly in a rougher and less effective way, owing to the present want of appropriate apparatus. In doing so the instrumental and other desiderata will be pointed out that seem most easily capable of being supplied, if the attention of a few persons interested in the matter could be brought to bear on the subject. Two things are at present needed—a desire among many persons to have themselves and their children accurately appraised, and an effort among a few scientific persons who have the special knowledge required for the purpose to systematize the methods by which this could best be done.

There appears at length to be a somewhat general concurrence of opinion that the possibilities of a child's future career are more narrowly limited than our forefathers were fondly disposed to believe. I

shall not endeavor to epitomize the many arguments *pro* and *con* in respect to such views as these, but will merely recall, in partial justification of them, the results of some inquiries into the life-histories of twins * that I published a few years ago. I took two categories of twins—those who were closely alike in their infancy and those who were exceedingly unlike—and I traced their histories up to the date of the memoir. It appeared that twins who were closely alike at the first frequently preserved their resemblance throughout life, subject, I may almost say, to the accident of a fever, or other serious illness altering the constitution of one of them, and laying the first foundation of a gradually widening divergence. I found not a few cases in which twins residing apart and following different professions at home and abroad still continued to live parallel lives, ageing in the same way, and preserving all along the same features, voice, gestures, and ways of thought. I also met with cases in which death had occurred at nearly the same time to the two twins, and from the same disease. It further appeared, as regards those twins who were born very unlike, that in no case did their dissimilarity lessen under the influence of identical nurture. They had the same nurses, the same tutors, the same companions, they were reared in every respect alike, yet their characters continued to be as dissimilar, and, I need hardly add, their features remained as different as if they had belonged to totally different families. The conclusion to which I was driven by the results of this inquiry was that a surprisingly small margin seemed to be left to the effects of circumstances and education, and to the exercise of what we are accustomed to call "free-will."

It follows from such opinions as these, which appear to be gaining ground in popular estimation, that it is highly desirable to give more attention than has been customary hitherto to investigate and define the capacities of each individual. They form his stock-in-trade, the amount of which admits of definition, whereby he has to gain his livelihood, and to fulfill the claims upon him as head of a family and as a citizen. So far as we succeed in measuring and expressing them, so far almost in an equal degree should we be able to forecast what the man is really fit for, and what he may undertake with the least risk of disappointment. They would encourage him if unduly timid, or they would warn him from efforts doomed to be wasted.

What I propose to speak of in the present memoir are those measurements of the bodily form and faculties that can, or apparently could, be made with some precision, but the personal data in respect to intellectual and emotional capacities, and to special aptitudes and tastes, require a separate treatment. The progress of the art of measurement of the more purely bodily faculties has been by no means uniform. It has never been specially directed toward furthering the

* "Journal of the Anthropological Institute," 1875; "Fraser's Magazine," November, 1875.

knowledge of the life-history of individuals, but for the most part toward other theoretical investigations. In some cases elaborate instruments and methods of observation have been devised by which certain faculties have been tested with extreme minuteness; in other cases no well-contrived and approved system of examination exists. If everything should be stated by which anthropometry might profit, the effect would be not unlike the map of some partially-settled country, drawn on a scale so large as to show the cadastral survey of its principal town-lands. A fraction of the whole would thus be minutely engraved, the wide adjacent regions would be represented by a few lines of route, and the remainder would consist of blanks. In order to convey in the best way an idea of what is known about such a country as this, the general map of it should be on a small scale, and then uniformity of treatment becomes possible. Acting on this principle, I shall avoid entering into details on those subjects where there exists very much to speak of, and shall nowhere go further than is sufficient to express the simpler requirements of anthropometry.

Let us, then, consider how we should set to work to define and describe the various bodily faculties of a person whom we had ample means of observing, say one of our own children. Some of the observations could hardly be made except at a properly equipped anthropometric laboratory; others, as it will be seen, could at present be carried on best in the play-ground. I shall not care to distinguish these in the description; they will be obvious enough when they occur. The tests would define the capacities of the person at the moment when he was observed. They are expected to be renewed at intervals, so as to serve as records of successive periods in his life-history.

Photography was the subject of my last memoir. I showed that the features should be taken in full face and in exact profile, and on not too small a scale—that of about one seventh of the natural size being, perhaps, the most convenient. I also spoke of other photographs in less formal attitudes, to show the whole figure and gesture. In some of these the limbs might be more or less bared to exhibit the muscular development.

I need not dwell upon the usual anthropometric measurements. They should of course be made, and probably no better rules can be followed in making them than those of the present Anthropometric Committee of the British Association. These measurements refer to height, to weight, to chest-girth (but only if taken by skilled observers on a uniform plan), to capacity of lungs (also under those conditions), and to color of hair and eyes. Other data are asked for in the instructions issued by the committee which would also require to be recorded, and which may as well be mentioned now—such as birthplace and residence, whether in town or country, both of the person and of his parents; also their race, whether English, Scotch, or Irish, etc.

We now proceed to the measurements and records that are more especially the subject of this memoir.

Energy may be defined as the length of time during which a person is wont to work at full stretch, day by day, without harm to himself, in obedience to an instinctive craving for work, and endurance may be tested by the same observation if an adequate motive for work be supplied. Some persons seem almost indefatigable; they are never happy or well except when in constant action; and they fidget, fret, and worry themselves under enforced idleness. Others, whose vitality is low, break down under a small amount of strain, and their happiness lies mainly in repose. The true tests would undoubtedly be physiological, and of considerable delicacy, but they have yet to be discovered, or at least to be systematized for anthropometric purposes. They would measure the excess of waste over repair consequent upon any given effort, and would furnish the indications of a loss of capital which, if persevered in, must infallibly lead to vital bankruptcy. Now, when a haberdasher examines a piece of cloth to learn its strength, he handles and pulls it gently in different directions, but he does not care to tear it to pieces or to strain it. He learns by the way it behaves under a moderate tension how it would support a great deal more of it. So it may prove to be with physiological tests, as applied to the determination of the amount of endurance. The balance of the living system might be artificially disturbed by a definite small force, and its stability under the influence of greater forces might thereby be inferred. Unfortunately, the only convenient tests of a person's endurance that are now available are records of such feats of sustained bodily or mental work as he may have recently performed, that were not succeeded next day by feverish excitement or by fatigue, but whose effects were entirely dissipated by a single night's rest.

The faculties about which I have next to speak admit of being developed in a high degree by exercise, and some difficulty will always arise in knowing how far their development may be due to nature and how far to practice. This difficulty is, however, of less importance than it might appear to be. All our faculties are somewhat exercised in the ordinary course of life, and when we begin to practice any special test, though our skill increases rather quickly at first, its rate of progress soon materially lessens, and we are able to judge with sufficient precision of the highest point which we can hope to attain. When recording the results of any test it would be sufficient to append a brief note concerning the amount of previous practice.

The strength is best measured by a spring dynamometer, of which the frame-work is held in the left hand with the arm extended, while the spring is drawn back by the right hand in the attitude of an archer. This is the test used by the Anthropometric Committee; it only refers to the strength of the arms, but that is in most cases sufficient to express the general muscular power, and it has the ad-

vantage of not causing injurious straining to weakly persons. Trials of lifting heavy weights are positively dangerous. If a multitude of persons were tested in that way, some instances of broken blood-vessels and of abdominal ruptures would be almost sure to occur.

Agility may be defined in terms say of the number of seconds required to run a hundred yards, of the greatest horizontal distance that can be covered by a leap, of the distance to which a cricket-ball can be thrown, and by means of various gymnastic feats. The several merits of the latter, however, require to be carefully considered, and those that can be performed in-doors and in a confined space should be selected as standards.

The co-ordination of muscles and eye is another faculty that varies widely in different persons, while it is also greatly increased by education. Some persons are gifted with a high power of accurate movement, while others are as notoriously clumsy. In all cases, however, this faculty may be largely developed in special directions, as is shown by the superior dexterity of artisans to that of amateurs. It seems a most simple faculty to be tested, nevertheless I know of no recognized methods of doing so; and, in default of one, the best plan of defining its amount might be, in the case of youths, by their measured skill in well-known games, as racquets, cricket, rifle-shooting, billiards, and wherever else a good eye and steady hand are required.

The faculty of sense-discrimination has in many respects been the subject of most elaborate experiments, chiefly in regard to the relation between the amounts of stimuli, as measured by objective standards (such as weight in pounds, as brightness in units of intensity, etc.), and the corresponding amount of evoked sensations, measured by subjective standards, namely, by the feelings of the several persons operated on. Out of all the contrivances that have been devised for these experiments, some of which are extremely delicate, we want a battery of the most simple ones that are sufficiently effective for ordinary anthropometric purposes. I find it difficult, in obedience to the programme already laid down, to enter as much as I should like to do into particulars concerning this wide and important part of the subject before us. The sources of error to be guarded against, the principles that have to be attended to, and the instruments already in use, can not be properly explained in a few paragraphs. The reader must take it for granted that all this is a familiar subject to many writers and experimenters, such as Fechner and Delbœuf, and that the work remaining to be done is to select out of extant instruments those that are sufficiently inexpensive and quick in manipulation to be appropriately placed in an anthropometric laboratory. Under these circumstances I will refrain from doing more than specifying the more important measurements among the many that admit of being made:

SIGHT.—Its keenness; the appreciation of different shades; that of different colors.

SOUND.—Its keenness; the appreciation of different grades of loudness; that of different notes.

TOUCH.—Discrimination of different roughnesses, such as wire-work of differently sized mesh.

MUSCULAR SENSE.—Discrimination of weights externally alike, but differing slightly in specific gravity.

Another class of delicate apparatus refers to the rate of response to stimuli. A signal is given to one of the senses, as by the sight of a suddenly lifted finger, by an exclamation, or by a touch, to which response is made by pressing a stop. The interval between the signal and the response is measurable, and it differs in different persons.

Another well-known arrangement tests the time lost in forming a simple judgment. Arrangement is made for two possible and different signals, which are severally to be responded to by different forms of response. The subject of the experiment is ignorant which of the two signals will appear. After he perceives it, there is an appreciable time of hesitation before he is able to make the appropriate response, and this time is easily measured, and is found to differ in different persons.

The persistence of impressions, especially if visual ones, is exceeding various. Some persons are strongly affected by after-images and others are not. For example, after gazing at a red wafer for a short definite time and then rapidly withdrawing the eye, the appearance of a green after-image will be present to some and not to others. There can be little doubt that the liability to after-images is an important factor of the artistic temperament, being the base of the enhanced susceptibility to conditions of contrast and harmony of colors. Numerous experiments exist bearing on various kinds of after-images, but they want systematizing for anthropometric purposes.

The memory, in its dependence on the relative impressions of eye, ear, and other senses, whether severally or in combination, admits of being tested, and here again numerous scattered experiences have been gained, and ingenious experiments have been devised which require consolidating and systematizing.

This is perhaps as much as need be said in a very brief general glance over a large division of a large subject. My object is to point out that means already exist for the appraisement of many of the principal bodily faculties, but that they require to be systematized, and that others have to be contrived, and that they can not be properly utilized for ordinary anthropometric purposes without such apparatus as would require to be kept in a laboratory and used under the guidance of an intelligent operator.

I will say a few words, and a few only, upon another large branch to which I alluded in my previous article, namely the medical life-history of each individual. There seems to be need for medico-metric

laboratories where certificates of observed facts should be furnished to any applicant for stated fees. These would contain as exact and complete a report of the physiological status of a person as is feasible in the present state of science, by the help of the microscope, chemical tests, and physiological apparatus. Laboratories of this description ought to be welcome to practicing physicians, who, being unable to keep the necessary apparatus in their consulting-rooms, could send their patients to be examined in any way they wished, whenever they though it desirable to do so. The laboratories would be of the same convenience to them that the Kew Observatory is to physicists, who can send their delicate instruments there to have their errors ascertained.

The data for the medical history of a man's life are the observations made by his physician in his successive illnesses, and I would dwell on the importance of gradually establishing a custom that the medical attendant of each patient should as a matter of course write down such clinical notes of his case as are written at the bedsides of public patients at hospitals. These papers would be for the private and future use of the patient, and would be preserved by him, together with the prescriptions. They would accumulate as the years went by, and would form the materials for a medical life-history of very great value to the patient himself in the illnesses of his later life. The records might be epitomized by his physician from time to time, and they would in that form be an heir-loom to the children of the patient, warning their medical attendants in future years by throwing light on hereditary peculiarities.

The popular object of this and the previous memoir is to further the accumulation of materials for life-histories in the form of adequate photographs, anthropometric measurements, and medical facts. No doubt it would be contrary to the inclinations of most people to take much trouble of the kind about themselves, but I would urge them do so for their children so far as they have opportunities, and to establish a family register for the purpose, filling it up periodically as well as they can. It will have been seen that much may be effected without special apparatus, and on the other hand that much more could be effected, and with increased ease and precision, if anthropometric laboratories existed. Should a demand arise for such establishments, it would not be difficult to form them in connection with various existing scientific institutions. A few shelves would hold the necessary apparatus. Something useful of the kind could be set on foot at a moment's notice, but it would require much practice and consideration by capable men before a standard outfit could be decided on.

The motives that might induce a person to take the trouble of getting himself accurately measured and appraised from time to time, and of recording the results, are briefly as follows: 1. Their biographical interest to the person himself, to his family, and descendants. 2.

Their utility, especially from a medical point of view, to himself in after-life. 3. The information they might give of hereditary dangers and vital probabilities to his descendants. 4. Their value as future materials for much-needed investigations into the statistics of life-histories.—*Fortnightly Review.*

LIBERTY OF THOUGHT.

BY REV. E. WOODWARD BROWN.

MY subject is the progress of freedom of inquiry; of liberty to investigate and discuss, to compare and contrast, to adopt and reject opinions—liberty to think for one's self in every direction. The subject is not the great life and war of thought, that which accompanies struggles of all kinds in the world—struggles religious, political, social, and industrial—but is simply the progress of thought out of an enslavement that has existed through the world in all time. The mind of man has been more or less forbidden to exercise itself as it pleases. A great work which it might have done and has not done, work of all sorts throughout society in all its departments, has failed because some men have forbidden other men to think in a different way from what those men willed.

The causes why men have repressed thought are found in a natural dislike of dissent from cherished opinions—in a natural illiberality owing to ignorance or pride of opinion, or in a vague fear that new thinking will in some way hurt one, or one's cherished opinions, as to how things should be; also in the advantage pecuniary, social, political or other, arising from some established system, civil, ecclesiastical, educational, or the like, which free discussion would endanger in whole or in part. Through these causes those who have had the power have used it to put down all objectionable thought.

In heathendom, whenever and wherever a great ecclesiastical system has prevailed there has generally been an enslavement of mind in all directions; and wherever a great absolute state has existed there has been an enslavement of mind in political and social, if not also in religious directions. To refer to the enslavement by ecclesiastical systems: in these instances the ecclesiastical power has shackled thought upon religion, morals, science, and literature, upon social and civil subjects, in short upon everything; has controlled absolutely the whole expression of the nation's mind. The priestly class have arranged, inspired, and regulated all the duties to God, to the state, to the family, and to society. The priestly body has also claimed the supreme control of education; has prescribed the limits and the courses in which it shall be lawful for the human mind or for the human being

to go; has also fixed the laws of literature and art, as we see in the conventional architecture, sculpture, and paintings of Egypt, Assyria, and Babylonia. This ecclesiastical conventionalism, supported by the popular superstition, has greatly hampered original thought.

This sacred fixedness has not allowed, on the one hand, any progress in the native mind itself, nor the influence upon it of foreign mind and foreign methods.

In Egypt we have a priesthood dominant and fixing all forms of life. In the Assyrian power we have the kings constantly exalting the gods, in proclamation and inscription; and the architecture and sculpture are of an ecclesiastical and unchanging pattern. In the Medo-Persian power the ecclesiastical authorities largely shape the people's life; and we find that part of the creed, that idols should be destroyed, enforced wherever the Persian arms were carried. In Hindostan we have religion setting conventional limits to religion, philosophy, science, art, literature, politics, and social life.

But, on the other hand, we also find liberty of thought. Buddhism has been tolerant and pacific; has propagated itself never by war nor by legal force, but only by moral suasion. China, too, seems to have allowed a measure of liberty of thought in everything but politics. Several religions exist there side by side; and philosophy, science, and literature are found without an ecclesiastical imprint.

In the ancient republican systems of government there seems to have been more or less liberty of thought, except in religion and politics. This was so in the Phœnician confederacy, in the Carthaginian commercial states, in the Grecian republics, and in the Roman commonwealth.

In the dawn of Greece we find the priestly class weakened and superseded by the military. The despotic colleges of priests which existed in the East never had a place among the high-spirited and independent chiefs of Greece, who are described in Homer and elsewhere as taking the offices of religion into their own hands, and in various ways keeping its ministers in check. Doubtless, the genius of the people also had something to do with this. Nowhere has there been more liberty of thought in heathendom than in Greece, more freedom from superstition and bigotry; and yet even the Greeks were intolerant. Anaxagoras, who tried to explain astronomical and meteorological phenomena, had a narrow escape with his life from the offended "piety" of the Athenians. It took all the influence of Pericles to save him. Socrates was put to death. Phidias was persecuted, and died broken-hearted in prison. Every honest man was, at one time, in danger of being accused of atheism by the zealots. Noble citizens were tortured. Yet, on the whole, "at the epoch of the highest glory of philosophy, Plato, Aristotle, and most of the philosophers, whether of Grecian, or, more latterly, of Greco-Roman antiquity, had full liberty of thought, or nearly so. The state's public policy inter-

fered but little with their labors, to cramp them and give them a particular tendency. They, on their part, concerned themselves but little about politics, nor cared much to influence immediately and decisively the society in which they lived."

Liberty of thought was allowed in Roman civilization, and yet, even there, was not permitted upon political subjects. The Roman method of conciliation was, first of all, the most ample toleration of the customs, religion, and municipal freedom of the conquered, and then their gradual admission to the privileges of the conquerors. Freedom of thought was allowed to a remarkable degree. Education was controlled neither by priest nor magistrate. Writing was free, and the circulation of popular works was extensive, though probably the rulers would have quickly restrained the circulation of what they considered injurious to the state. Public speech was free upon philosophy and morals, and upon theories of government, liberty, and tyrannicide.

While Mohammedanism has fixed unalterably its doctrines and forms, and has allowed no discussion of them, and so far has been inconsistent with freedom of thought, still it has permitted a measure of free thought. Its followers do not regard infidelity or heresy as criminal, and persecution for theological opinions has not been their rule. They have never had an Inquisition; or the burning of an unbeliever under authority of law. They have always allowed conquered Christians to retain their faith, and even to have public worship. No wars of compulsory conversion like those of Charlemagne, no expulsion of unbelievers, like that of the wars of Spain, stain the record of Mohammedanism. The succession of the Greek Patriarchs of Constantinople and Jerusalem has been regular for more than four centuries, and their relations with the Sultan have been far more amicable usually than those of the Pope with the kings of France and Germany.

The Koran says, "Those who are Moslems and those who are Jews, and the Christians and the Sabeans who believe in God and the last day, and work righteousness, for them is their reward with the Lord, and there is no fear for them, and they shall not be put to sorrow." Many of the caliphs invited Christian scholars to their courts, and were glad to have Christian students in their schools. The Caliph Haroun-al-Raschid employed Nestorians as head teachers. In the tenth century ambitious young Frenchmen went to the Asiatic schools of Spain. For instance, there Gerson, afterward Pope Sylvester II, was educated.

We now come to the progress of liberty of thought in Christendom.

The Christian Church has been afraid of inquiry because, so far as it makes unsound and false statements of fact, contrary to those of the Bible, it tends to unsettle the minds of men in what is regarded

as accepted and very important truth, and so she objects to every one reading what she considers to be infidel books.

But, again, portions of the Christian Church have opposed inquiry because it made true statements which contradicted certain wrong interpretations and inferences that the Church had made from Scripture, and so, in undermining the errors of theology and the Church, seemed to be undermining the important truth, and, while in reality doing a good service, seemed to be doing harm. For instance, investigation of the laws of nature has ever been supposed by many "to be doing away with the being or the perfections or the providence of God; the discovery of second causes has been thought to detract from the glory of the Great First Cause." The discovery that God works by law, or with regularity, has been supposed to interfere with the faith that he is personal, has a choice to do this or that, and interferes among men for or against. A class of thinkers have assumed that, at least in some spheres, God acts without the aid of second causes, and frequently without regard to uniform laws—acts irregularly. Science has been steadily reducing the extent and the number of such spheres, but in the case of every one there has been a battle offered by those who believed that in that sphere God operated without regard to law; that there man should not look for regular laws or for secondary causes, and that to do so is presumptuous if not irreverent and impious. In this way good men and great men have shown themselves opponents of real science; have made the mistake of assuming that their prejudices and views were in harmony with the spirit and the views of the Bible, or of true religion. These men have supposed that they and the Bible were at one, and have been mistaken. They have undertaken contests in which they were defeated, and in which it became afterward apparent to the Church at large that they were mistaken.

This opposition of portions of the Church to mental liberty is contrary to the original views and practices of the Church. And the right has also been disputed by worthy men, such as Ambrose, Hilary, and Martin, within the Church. The Christian religion is not accountable for this false position of the Church toward freedom of thought.

Let us now look at the mental enslavement in Western Christendom. Strange to say, that great Christian Church which has played such an important part here, has, as before intimated, been guilty of such enslavement; has, with all its illumination on many subjects and its great power, been an opponent of freedom of thought; has been hostile to views of Scripture and doctrine different from the accepted views of the day; has considered all expression of divergent views as exceedingly bold, if not irreverent and heretical. For centuries the clergy and the monks directed the whole current of European affairs, personal, family, community, or national; scientific, literary, philosophical, or theoretical. The clergy and monks were a body by them-

selves, a hierarchy, a caste, a class that had undertaken the intellectual as well as much other schooling of Europe. They ruled in and throughout every sphere. They fixed everything in thought, religious doctrine, general philosophy, science, art, poetry—all. In a great measure they formed and controlled public opinion. They fashioned after their own views the minds of youth.

All this was well enough for a time. Europe needed it, and the gain was greater than the loss; better almost any education than no education; not but that their education was the best, but there comes a time when formal education by human teachers must cease—when "school is out"; and when this time arrived in Europe, and here and there men were in thought beginning to go without their teachers and beyond their teachers, then the Church, instead of, like a wise father, letting them go, tried to hold them.

The Church had become lifted up with the idea that theirs alone was the wisdom which could train, and theirs alone was the right to train; that it was their legitimate business. And so they tried to regulate thought—all the thought of the world so far as they could reach that world.

Learning was oppressed, original speculation in philosophy, original research in science, were prevented. Human reason was bound, for woe to him who claimed to find in metaphysics, mathematics, or the physical sciences that which contradicted what was stated! "The habit of doubt, the impartiality of suspended judgment, the desire to hear both sides of a disputed question, the going beyond what was taught," the making discoveries, all were condemned. Freedom, the condition of true inquiry, was cursed. Blind, unquestioning acceptance was blessed. The people were allowed a literature of imagination, but the effort was made to strictly keep them out of any moral and physical truth other than Rome had provided.

We now come to the change of the tide, to the beginning of better days for inquiry, to the dawn of the day of liberty. While liberty of thought was always more or less asserting itself, still, after a while, such assertion increased in emphasis and force. Several facts were favorable. It seems that, after all, the Church admitted the principle of freedom, for she advocated free thinking for herself. She maintained that religious belief and practice should not be brought under the absolute control of the civil government, and, by this assertion of the independence of the spiritual and therefore of the intellectual world, she prepared the way for the independence of the individual in these worlds. The language she held for herself as a whole, for herself in matters of religion and conscience, and for herself in the intellectual sphere, led the way for similar language by each person for himself.

Another great gain for freedom of thought was when secular government began to think for itself in its executive, legislative, and judi-

cial departments; when each state began to declare that, in political matters, it was independent of the Church.

Still another great gain was, when a few "mighty though solitary persons" in the twelfth century, the first scholastics, asserted the right of human reason to be heard and to be consulted in the formation of opinions, as against the mere say-so of the Church; though most of these persons forbore to attack commonly received opinions upon religion; but they revolted from blind acceptance of everything the Church said. They went to work timidly. They would believe in part because the Church said so, but they wanted that belief supported also by reason. The inference would be that reason had also some claim to be heard; a further inference might be that these men were rationalists, and would only believe what reason could comprehend, but that would not follow. They only did not want to believe what contradicted reason, and they wanted the privilege of supporting their belief by reason so far as they could.

Abélard, founder of the scholastic philosophy, began the great battle. The first shock of the strife was when he threw down the gauntlet about reason, and St. Bernard, a very distinguished divine of the day, took it up. Both were men of great genius, leaders of great parties, and both were bent on reform. St. Bernard was a monk, humble, self-denying, and modest. He was celebrated for his penances, his poverty, his devotion to the distressed, as well as for his learning and eloquence. He had attacked the vices of the monastic world, and was reforming it with great zeal. It was a fight between giants, and Abélard was beaten—he was silenced.

A friend and disciple of Abélard, Arnold of Brescia, advocated liberty of thought, while he also championed the rights of the people all around to act and live as they pleased, so far as the ecclesiastical body then dominant was concerned. And, so far did this revolution go, begun by Abélard and Arnold of Brescia, that it seemed at one time likely to antedate the great religious revolution of the sixteenth century by nearly four centuries. Free, independent thinking, with heresy, was rife in all the schools. A republic existed at Rome. The most fertile of the French provinces, Languedoc, was in the power of the Albigenses. But as Abélard was silenced, so Arnold was hanged. The Roman Republic was suppressed. The Albigenses of Languedoc were exterminated. The cause of liberty came to grief, and yet the good work of emancipation was not ended.

Another great gain for free thought was in the early national literatures. They were uncompromising foes of Rome, its vices and its tyranny over thought. Petrarch denounced the Roman hierarchy, popes, cardinals, and monks, with unmeasured severity. He poured out a torrent of invective. Dante showed the ideal church, and then contrasted with it the real Church. He put popes into hell, and called Rome the very Babylon that John saw in the Apocalypse. Boccaccio

treated the popular religious teachers with unbounded ridicule. The Minnesingers of Germany expressed freely their hatred of the tyranny of the Church; and the Provençal bards of France were unsparing in their attacks upon the hierarchy, until they were silenced by the fatal Albigensian crusade. The rising popular national literature of England indignantly censured the monks and higher clergy, and spoke out boldly against the whole hierarchical system. The famous "Vision of Piers Ploughman," by William Langlande (A. D. 1362), one of the earliest pieces of English literature, is from the pen of an earnest reformer, "who values reason and conscience as the guides of the soul, and attributes the world's sorrows and calamities to the wealth and worldliness of the clergy, and especially of the mendicant orders"; while, also, Chaucer, in his "Canterbury Tales," shows himself in full accord with Wycliffe in hostility to the mendicant orders.

In many of these early writings, reverence for the Church and religion is blended with bitter censures of the arrogance and wealth of the ecclesiastics. The spiritual power of the Pope is distinguished from his temporal power. The one is revered, the other denounced.

Again, we have the beginning of free thought in criticism in the idea of the comparative study of religion, as seen in the work "De Tribus Impostoribus."

Further, we have the beginning of free thought in philosophy, to wit: in the Mohammedan philosophy of the great infidel Averroes, introduced into Christendom from the Mohammedan universities of Spain; and there was also a struggle of the Church with Averroism, the subject of conflict being the nature of the soul, and the doctrines of emanation and absorption.

Furthermore, we have an effort at free thought in science. There were the leaders of science, Raymond Lully and Roger Bacon; there were also the Platonists—Barbarus, Curanus, Ticinus, Patricius, Picus, Agrippa, Paracelsus, Fludd, etc.; and again the theoretical reformers of science—Telesius, Campanella, Bruno, Ramus, and Melanchthon.

Moreover, there were discoveries which tended to diffuse knowledge, and so to awaken the mind of Europe—the art of making paper, the invention of gunpowder, and the discovery of the magnetic needle. There were, also, the universities. Instead of the Church being exclusively the only tribunal of opinion, the universities became now also centers of thought, with opinions and power of their own. Thus a certain new supremacy sprang up in the world of thought—a supremacy generally in accord with that of the Church, but sometimes antagonistic, and always more or less separate from it in the sphere of philosophy, science, and letters, here claiming to have an opinion of its own, and the claim being to some extent allowed.

Again, free thought found help in the jurists. They hated the Papal tyranny. Their study of the scattered remains of Roman law

and civilization tended to generate mental freedom from prejudice and from authority.

We also have help to free thought in the revival of classical learning. In the twelfth and thirteenth centuries, among the many complicated causes which it would be difficult to trace, a general revival of Latin literature took place, which greatly modified the mental state of Europe. For the first time in centuries we find, feeble though it be, an uprising against the universal credulity and against the universal passion for theology. There was a strong desire for secular learning beginning to stir the mind of Europe. A taste was developed for philosophy, science, letters, and classical learning, an intellectual life which, while more or less suppressed in one land or another, one generation or another, by civil or ecclesiastical despotism, was destined to increase all over Europe and to continue until the present. Men thronged the universities to study not only theology, but also philosophy, law, medicine, science, *belles-lettres*, and the old literature of Greece and Rome. A desire arose among men to think for themselves in every sphere of thought. At this revival there was introduced into literature that principle of freedom to think which the Reformation brought into religion, and which principle Cartesianism brought next into philosophy; and, next, the French Revolution, four centuries from the beginning of the general movement, brought into politics.

Again, we have the rise of free thought in religion. Church tyranny was encountered by a resistance within the Church itself, which resistance could not be overcome. Many could not be restrained, confined, and controlled by the Church. Nowhere, in fact, did individual reason more boldly assert itself than in heresies and sects in the Church—in their denial of the infallibility of creeds, councils, and popes. The long rule of orthodoxy was broken through by many heresies, which, though often repressed, broke out again as often, and with new force and consistency. The minds of the learned were perplexed by sudden doubts concerning the leading doctrines of faith.

Every sort of new opinion in religion was entertained, notwithstanding ecclesiastical authority. An impartial philosophy was proclaimed by Abélard. A stern and uncompromising infidelity was taught in Seville and in Cordova, which infidelity began to overshadow the mind of Christendom. A passion for astrology and for the fatalism it implies revived, though there was, as yet, no general disposition to rise above the traditional teachings and fixed systems of the Church.

The Reformation was, among other things, an assertion of liberty of thought; was a partial emancipation of the mind of Western Christendom from bondage; was a teaching man to think for himself in the specific instance of the claims of the Romish Church to control all in religion; was, if not a complete emancipation, at least a great increase of liberty. This, in Germany, Denmark and Holland, England and

France, and, for a time, in other lands where the Reformation was afterward crushed out, was a power of mental freedom.

Yet mental enslavement continued. The reformers would only change the master. He certainly was not to be the Roman Catholic Church, they said ; he was only to be a more legitimate power. Standards were still set up, and ecclesiastical and civil power stood behind them, to compel religious, philosophical, scientific, and other thought, not to differ from them. Every one, Romish or Protestant, claimed the right to defend and to propagate opinion by force ; every one was in favor of calling in the civil power to aid in a controversy in thought. But matters have much improved in the ecclesiastical sphere during these last four centuries. There is now marked progress in liberty of religious thought. The fierce invectives once hurled back and forth between Protestant and Catholic are dropped. The war of denominations has largely ceased. Convictions seriously entertained are now generally respected. Although a change of religion, or even in ministers a change of denomination, frequently causes more or less petty persecution, still there is improvement since the time, several centuries ago, when the apostasy of any one from the rest was regarded as one of the worst of crimes. A change of religion or even of denomination, from a sense of duty, is now commonly allowed among intelligent men. To-day the Protestant nations and the Roman Catholic countries of France,, Spain, Italy, Austria, Bavaria, and Spanish America, have abandoned intolerance and enjoy freedom of opinion.

There is also marked progress in liberty of scientific thought—in the seventeenth century, that freedom to prosecute and publish investigation in science, which is so necessary to the advancement of science, hardly existed as yet. Though the political influence of the Church of Rome had much diminished, though European society had largely passed from the dominion of the Roman Church to that of temporal governments, yet that Church, though less tyrannical, freer from abuses, and more tolerant than before, was still disposed to maintain at every point the doctrines and opinions already expressed upon questions of science and learning ; while also in Protestant lands popular prejudice still to an extent repressed mental freedom.

But there arose practical reformers in science—Leonardo da Vinci, Copernicus, Fabricius, Galileo, Kepler, and Tycho Brahe. Science began to make decided advances in geography, astronomy, chemistry, physics, anatomy, medicine, geology, political economy, and other branches. The conflict with the astronomers is well known and has been well described—the fear of Copernicus, the imprisonment of Galileo, the burning at the stake in Rome of Giordano Bruno for upholding the teaching of modern astronomy as to the immensity of the universe and the plurality of worlds.

Still liberty of thought in science began to grow in various lands, giving us Bacon, Harvey, Descartes, Hooker, Barrow, Newton, Locke,

Condillac, Helvetius, and others. In the present century all force has ceased, though certain advances in science have awakened opposition —for instance, the teaching of geology that the world had existed for millions of years, and had taken its shape under natural laws. This was thought to be against the Bible ; so, too, vaccination and anæsthetics and other new things have been opposed with unnecessary haste and heat, as devices to defeat God's will. But to-day science and philosophy are free in many lands, while the narrow and restrictive policy which still obtains in others is gradually yielding.

Freedom of political thought is largely increased, though despotism and obstructive social systems have been much in the way ; but, as the civil despotisms have changed into constitutional governments, there has been a steady increase of freedom.

Freedom of publication has likewise increased. In the middle ages nothing was allowed to be published that was against the opinions of the ruling powers in church or in state, nothing in theology, philosophy, science, or literature ; though of course this tyranny was by no means complete, and very many were the attacks on received opinions. Still, as a rule, the press was enslaved. Despotic governments in church or state have not allowed a free press, except in instances of a mild sovereign or upon matters foreign to any interest of the rulers. The general policy has been to forbid all utterance that in any way is subversive of the authority or influence of government. We have heard much of regulation of the press, in political matters, which means despotic interference with it ; the governments have been afraid of it ; the upper classes in church, state, society, and industrial enterprise, have been afraid of it ; it is rather the mouth-piece of truth and of justice for the people ; wherefore "the complete proper liberty of the press is the conquest of a high civilization."

In France the Revolution witnessed the freedom, even the license, of the press. Bonaparte followed. He feared and hated free thought, and was, in some directions, its persistent opponent and oppressor ; he exerted the immense power which he possessed to trammel the press ; he cherished a mean jealousy of every kind of intellectual superiority which he could not enslave.

In Austria, Spain, and Italy, under their despotic governments, influenced more or less by the priests, a strict censorship has been exercised over all thought interfering with civil or with ecclesiastical despotism. Yet, since the civil absolutism has decreased, the liberty of the press has increased, until now, in Italy at least, it is complete.

The English-speaking lands have a free press ; so, I believe, have the Spanish republics of America, and the same is true of Germany, Holland, and Belgium, and to a less extent of Scandinavian countries. In all these lands the principle has largely prevailed that writing and publishing are in themselves indifferent matters to government.

Such is a review of the progress of liberty of thought, especially

in Christendom—a review that evidences the fact of progress. There was never before a period when men were judged so little according to their belief as now, and when all studies were pursued with such freedom. The victory of toleration in the purely intellectual sphere has been almost achieved. The principle is almost established that there shall be no restraint upon thinking, speaking, or publishing, whether it be in theology, in philosophy, in criticism, in science, in literature, or in politics. Both the law and public opinion favor such liberty.

A REPLY TO MISS HARDAKER ON THE WOMAN QUESTION.

BY NINA MORAIS.

TO classify phenomena as manifestations of a universal law is the intellectual pastime of the nineteenth century. The finding of a Rosetta stone which shall be the key to a bewildering maze of details is a mental rest to the thinker. Hence, a theory which settles a much-vexed question by a scientific *ipse dixit* is met with a murmur of admiration and a sigh of relief. But those who profess to hold a commission from Science should not the less be bound to the "scientific rule of deducing no principle which facts will not prove." What Science says, facts will corroborate, but they will not always wait upon the interpretation of her devotees. About fifty years ago a gentleman of high scientific attainments proved by irreproachable mathematics that no steamship could cross the Atlantic, for by no expedient could a vessel be built which could stow away enough fuel to propel itself to so great a distance. To-day the gentleman might take as an ordinary trip the journey he proved impossible.

In the March number of "The Popular Science Monthly" Miss Hardaker invokes Science to testify to the natural and irrevocable mental inferiority of the female to the male. A statement of this kind, coming as it does when woman is struggling for every step in her intellectual advance, is peculiarly baneful to her. To cover ancient prejudice with the palladium of scientific argument is to unite the strength of conservatism and of progress in one attack. An examination of the accuracy of the paper, "Science and the Woman Question," may not, therefore, be ill-timed.

Two propositions underlie Miss Hardaker's argument. They are as follows:

1. A large amount of matter represents more force than a small amount. Hence man is superior to woman in body and brain (page 579).

2. "All human energy is an exact equivalent of the amount of

food consumed and assimilated." Man, by reason of his larger organs, eats and assimilates more food than woman does. Each of his organs, including the brain, is therefore capable of acting with proportionally greater energy. Hence, "men will always think more than women" (page 583).

Collaterally our author finds that the demands of maternity must cause a large subtraction from the smaller amount of mental energy which women would otherwise exert, and, as the result of her fundamental propositions, she draws the startling conclusion that "unless woman can devise some means for reducing the size of man, she must be content to revolve about him in the future as in the past" (page 581).

Before entering upon the question by means of her own original and scientific method, Miss Hardaker makes the following statements: "Students of physiology see that a final and conclusive law can not be drawn from differences in brain-weights and measurements, because of the present imperfection of data." But the superior power of the male brain, like the superior power of the male muscle, is shown conclusively by its product (page 578).

The figures which begin Miss Hardaker's argument are those which all speculations regarding the brain take into consideration. These figures are quite complete enough to indicate distinctly that the average male brain is always larger than the female. Miss Hardaker herself states that "all accepted authorities agree that the average male brain exceeds the average female brain in weight by about ten per cent" (page 578). Now, if the principle that bulk is power were admitted, the measurements obtained would be nearly, if not quite, conclusive of the natural superiority of the male: it would not have been reserved for Miss Hardaker to make the discovery. Miss Hardaker can not afford to dismiss brain-measurements as incomplete evidence, for these statistics become the key-stone of her own logic when she endeavors to prove man's mental superiority because of his excess of brain.

The student, however, does not reason as Miss Hardaker reasons. He, as well as she, possesses the historic fact that the product of the masculine mind has always been greater than that of the feminine. He might, therefore, find that, as the male brain has been more productive, it is the better organ. Upon this point Miss Hardaker contends that not only can we reason to the general quality of organs from their respective products, but we can actually arrive at a knowledge of their structure by such processes of logic. "We do not examine a muscle," she says, "to ascertain its internal structure" (page 578). If this were true, the occupation of the anatomist would be gone: the valvular arrangement of the heart, the cellular formation of the lungs, would have been disclosed by an observation of the externally perceptible operations of these organs. The truth is, that we can never rea-

son from product to structure until after we have internal evidence of the functional relations between the structure and product of the class of organs to which those under test belong; nor can we without such knowledge even reason to the general quality of two organs by their different product, unless our comparisons are made under the same environment. For instance, take two pairs of lungs: let one respire at sea-level, the other at the top of Mont Blanc. Their absolute product would be no estimate of their relative capacity. Still, the physiologist would have little difficulty in eliminating the effect of difference of circumstances in his calculation, because his complete knowledge of the lungs and of the influence of atmospheric pressure enables him to allow for differences of environment. But no such allowance can be made in estimating the normal power of the male and female brain which have always acted in different mental atmospheres; for the relation of structure to function as regards brain has not been accurately determined.

It is because of this lack of knowledge regarding the precise connection between brain-structure and thought, and not because of imperfection in the data of measurements, that students refuse to draw therefrom the law of brain capacity; and thinkers will not infer the capacity of male and female brains from their products, until the different influences acting upon men and women can be eliminated. While anatomy is unable to solve for us the enigma of sexual brain-power, we may have recourse to comparison under similar environment as the key to our problem. This method of discovery Miss Hardaker, with a perversity remarkable in a disciple of modern science, is laboring zealously to prevent.

"We need not," she says, "ascertain the meaning of brain-size by experiment; we can arrive at it by analogy. All other organs (under the same conditions) work in proportion to their size. Is there any good reason for making an exception of the brain?" (page 578). Now, even if all other organs work in proportion to their size, the fact that the brain is exceptional, in the nature and in the variety and complexity of its functions, would render the argument from biceps to brain as questionable as that from marble to zinc. There may be properties in common, but in the production of forces the similar effects of these common properties may be wholly vitiated by others peculiar to only one of the objects compared. Besides, size is not always a gauge of organic capacity. Does the large eye see better, the large ear hear more, the large nerve feel more keenly? And, if, all other conditions being equal, they might do so, the incalculable variation of condition renders the size test of no practical value at all. This, however, is a phase of the subject to be discussed later, when we shall endeavor to show that, although we agree with Miss Hardaker that a larger brain means something, it does not necessarily mean a "greater amount of thinking in a given time." And, here we throw in, as interesting

facts, that woman's smaller heart beats faster than man's larger one; that her circulation is to his in swiftness as ten to nine; and that, according to Miss Hardaker's figures, and to some celebrated authorities, the proportion of brain to body is larger in woman than in man.

But to meet Miss Hardaker upon her own ground in the discussion of her fundamental propositions, we shall waive, as she has done, all sexual differences, of physical or local environment, and all analogical inferences, and proceed to compare the male and female brains upon a supposititious level of like conditions. She proposes to prove, on quite new and highly scientific grounds, that absolute weights and measurements are, after all, the ultimate tests of capacity. It may be deemed singular that the profound students who have preceded Miss Hardaker—some of whom were undoubtedly scientists—should have entirely overlooked the beautifully simple conclusion she formulates, thus: "If mass represents force, the larger the brain, the larger the power." The reason why students have been so blind to Miss Hardaker's discoveries is quite as simple as the discovery itself. It is because her premises are false.

A large amount of matter does not represent more force than a small amount, nor does it represent any force at all. There is an elementary law of physics which declares that the momentum of a body equals its size multiplied by its velocity, and this may lead to the supposition that matter itself is force. But matter in a state of inertia is not power; it becomes powerful only when acted upon. The same force acting upon different bodies imparts velocity in the inverse ratio of their masses; and, since velocity as well as size is a factor of power, it follows that a force which imparts a greater velocity to a smaller body gives it as great a momentum as a larger body obtains when acted upon by the same force; for the velocity in the latter case is feebler. Even admitting (what Miss Hardaker does not appear to claim) that *potential* energy may be proportionate to size of mass, we see that potential energy can only be evolved by an appropriate force acting through or upon the mass, and, to make the potential energy of a large mass do more work than that of a smaller one, the force applied must always be greater. Hence, not the size of the body, but the strength of the impelling force, is the ultimate test of its power. A glance at obvious facts will show that size is not the gauge, that weight may indeed be a direct impediment to the evolution of force. The avoirdupois of the fat boy is a clog to his energy; the fast runner wins by his light weight; the champion oarsman reduces his flesh.

In applying her theory to the brain, one fact which Miss Hardaker herself states is sufficient to tell very disastrously against her conclusion that larger brain-weight means larger thinking power. "According to Gratiolet, the male brain can not fall below thirty-seven ounces without involving idiocy, while the female may fall to thirty-two

ounces without such result" (page 578). Here are two brains precisely of the same quality, one thirty-seven ounces the other thirty-one, an absolute difference of six ounces. Yet these six ounces represent just nothing. Indeed, give the woman thirty-four ounces and leave the man thirty-seven, his three ounces more are simply a minus: thirty-four is rational thought, thirty-seven irrational. In this instance a *small amount of matter represents more power than a large amount.* It would seem that the true law must be sought elsewhere than in the grocer's scale.

But the impelling force which Miss Hardaker omits in her former statement is supplied in her next assumption: "All human energy is derived from food. Man eats more than woman because his larger size requires him to do so, a larger proportion of nourishment is sent to his brain; hence men think more than women." A look backward at our elementary law of physics will show that Miss Hardaker's second conclusion is as weak as her first. To repeat that portion of our law which bears upon this argument, we find that the same force acting on different bodies imparts velocity in the inverse ratio of their masses, and it is therefore clear that, in order to make the large machine run *as fast* as the small one, fuel must be supplied to the former more freely. The explosive force that sends the tiny rifle-ball at the rate of twenty miles a minute could not overcome the inertia of the missile discharged from the Krupp gun; a proportional force to each would send each just the same distance. Now, granting all the premises of Miss Hardaker's second proposition, that male and female eat in certain fixed proportions, that a certain fixed amount of that proportion goes to nourish relatively proportioned brains, the only logical conclusion is that the *larger brain,* supplied with *more blood,* would in a given time do heavier work, but not more work, than the smaller one supplied with less blood. Under these circumstances the momentum of the larger brain would be greater than that of the small brain; their velocities equal. Without his extra supply of blood, man's brain *could never overtake woman's in velocity;* indeed, without this additional stimulus it might not be able to move at all. The theory that the smaller brain is propelled more easily, might explain the quickness of perception and of fancy which, according to Miss Hardaker, are womanly traits.

Such reasoning, however, is at best mere theorizing, for it applies the simple laws of mechanics to the intricate and so far inexplicable structure of the brain, making no allowance for complications which would divert the action of the law. It may be true that blood is the primary motor of the brain; but there are many other elements besides the size of brain and body, or even the amount of food assimilated, which measure the quantity of blood sent to the brain. The problem is by no means, as Miss Hardaker has tried to make it, an easy sum in simple proportion which the school-boy may solve standing on one

foot. Omitting altogether a consideration of the superior blood-circulation of women as a class, overlooking entirely the probability (indicated by the data of the idiot question heretofore discussed) that proportion of brain to body is an element in the capacity of the former, the individual rapidity of circulation, the richness of food in brain-making material become important terms of our problem. The opium-eater, the wine-drinker, the consumer of brain-stimulants, certainly drive more than a proportional share of blood to the brain. At the same time there is always a personal equation to vary the proportional action of food-supply. The brains of Moses and Mohammed were stimulated by prolonged fasts. The circumstances of travel, temperament, companionship, wealth, the passions, music, art, dancing, machine-stitching, and a thousand others, which can never be averaged, often exert an adventitious influence on the appropriation of fuel for thought. These influences are entirely independent of food-consumption and brain-size; they defy the application of any law of mechanics.

But Miss Hardaker's scientific argument, if true, proves too much; for if men, the greater consumers, think more or even better because of the large size of their bodies and the larger power of their digestive organs than women do, then it must follow that the larger and healthier men as a class must think, if not more, at least more profoundly, than smaller and less robust men. Yet the bulk of the world's thought has not been done by men of superior physique or even of superior health. Aristotle, Napoleon, Jeffrey, Thiers, were short in person; Shakespeare, Buckle, Comte, were delicate in frame; Descartes and Bacon were always sickly; Heine wrote his best while in physical agony; Newton and Spinoza were slight in form and of medium height; Herbert Spencer's health has always been precarious; Mrs. Browning was a life-long invalid; while, unfortunately for a theory based upon superior digestion, Goethe and Carlyle were confirmed dyspeptics.

The instances here cited are by no means exceptional. Indeed, the seeker for data under this head will find that, instead of larger and more healthy physiques evolving a larger average amount of mental power than smaller and less robust ones, the contrary result is emphatically true. As a matter of fact, the circumstance of superior muscular development seems unfavorable to great exertion of the mind. The demands of the body itself are in large men imperative. The waste of the system must be repaired, and the first draughts of energy must go to this purpose. Afterward, though the potential energy represented by the food consumed may still be stored up, there is little power or little inclination to apply that energy to thought. The college student who is most active in the field, who has the greatest height in his stockings, and the biggest biceps, is rarely at the head of his class. Not only does the larger body require more in proportion

for its nourishment, but the forces which effect this nourishment are not easily turned in other directions, and it is, therefore, a natural sequence that the body must dwindle as the power of the mind increases. The savage Teutons, whose great bodies affrighted the Romans of Cæsar, have become the civilized possessors of less bulk and more knowledge. Human energy appears not to be harmonious, but to run in grooves. Thought produces thought, and the energy once sent to the brain is the direct cause of a new demand for supplies. In like manner, the arm that is developed by work needs a larger amount of food for its maintenance. This is the explanation of the historic fact that physical and mental powers have never been proportionally cultivated, but always at the expense of each other. The profound thinker and the superior pugilist are rarely united.

But, even if it is true that the larger and healthier *physique* affords more blood for brain-use, it does not follow that the larger the supply the greater the amount of brain-work possible. The argument assumes that the brain has no limit to its activity except in the quantity of blood that can be prepared for it. But it needs no scientific education to know that there are other influences which limit the thinker's activity, and that these limitations are somewhere in the mysterious recesses of the brain, or in the forces of which the brain is the organ. The physical health of the brain-worker may be perfect, his digestion unimpaired, his power to assimilate food the same, and yet he may not be able to concentrate his thoughts or carry on a complicated train of reasoning. The defect is not in his body—that is as healthy as ever; nor is it in any of the processes of blood-making—these go on as before. The trouble lies in the brain itself, whose capacity for work is measured by some hidden standard of its own, and which gives warning when a cessation of brain-work is imperative. The body is a furnace whose power of consuming fuel is greater than the capability of its boiler—the brain—to generate power. To keep the latter in good working condition, something more is necessary than building and feeding the fires. A supplementary but important consideration is, whether the steam beyond a certain point will not be productive of unpleasant consequences in the form of an explosion.

In the discussion of the collateral question, that of the effect of maternity on brain-power, Miss Hardaker's scientific logic takes its most amusing form. "The necessary outcome of absolute intellectual equality of the sexes," she says, "would be the extinction of the human race. *For, if all food were converted into thought in both men and women, no food whatever could be appropriated for the reproduction of species*" (page 583). What Miss Hardaker really means by this last highly scientific axiom it is impossible to guess. She can not mean that, as all food *is* converted into thought in men, women must cease to be mothers in order to imitate his food-conversion. Whatever Miss Hardaker may intend by her impossible supposition, the fact that ma-

ternity does make large draughts upon the energy of woman is not to be overlooked. But, unless it can be shown that the mental activity of man is ceaseless, that his manual labor diverts no blood from the brain, that his imaginative and reasoning powers keep steadily at work year in and year out, limited only by supply of food, it does not necessarily follow that women must fall behind men in the brain-work of a lifetime. Both men and women need mental rest—no brain-worker can keep at the top of his speed for ever; and women whose duties as mothers divert their energy from the brain may overtake men in their voluntary holidays. This fact will have more concrete significance when we reflect that the professional brain-workers in both sexes are in the minority, and that women who are such are usually unmarried, or mothers of small families. At the same time, the labors of men who form the great masses of population are not more stimulating to brain-culture than the vocations of their wives. But, granting what is probably true, that woman as a whole can never show as much mental product as man, because some of her time and energy must be devoted to motherhood, still she may be quite as capable of production. Therefore, any reasoning which excludes women as a class from the advantages of equal mental training with men, on the ground that they must be the mothers of the race, is forcing the activity of women into one channel, and rendering all other efforts (such as the writing of a scientific article, perhaps) unnatural and unwomanly.

But suppose the whole of Miss Hardaker's argument to be founded on true premises, and all her conclusions to be just and accurate, it may yet be pertinently asked, *Cui bono?* Miss Hardaker would slam the educational doors in women's faces because, being smaller, they are unfit to enter the select retreats of Brobdingnag. But, if justice is to prevail in the rules of admission, the woman who possesses a brain of fifty-six ounces is entitled to precedence over the great majority of males whose brains weigh only forty-nine and a half. Should the environment be more favorable to the woman whose brain-weight is forty-four ounces, she can claim the advantage over the larger male brain whose environment is less favorable. Then, too, the applicants for entrance must be subjected to the test of an eating-match, and the dyspeptic must consent to suicide or rejection. All this must be done, for, although Justice carries her scales, she is blindfolded. She can only weigh brains, food, environment, but can not see the sex of suitors for admission into the new academy. Miss Hardaker must be aware that, were every element in her assumptions true, some women must be greatly superior to the average men, although the highest point reached by the male could not be obtained by the female. Miss Hardaker would, perhaps, object to having the doors of journalism closed against her, because she can never think as profoundly as Lord Bacon, or because in general woman's literary production has not made so fair a showing as man's. It is not long ago since this sort of reasoning

militated strongly against the publication of any article that might be signed with a woman's name. But science—not the false science which answered Miss Hardaker's invocation, not the science which would confine the negro to slavery because of his small brain and small mental achievement—true science says that, if woman's power is to be judged by her work, she must be given a fair field for its display. To clear the race-course for the man, and to block woman's road at a certain point, because we feel intuitively that she can go no further, is by no means consistent with modern scientific methods. If the line of woman's power is marked, let her discover the fact, as Bacon thought—all scientific truth should be discovered by experiment. The discovery will not long be delayed; the law of the survival of the fittest will not be abrogated. But, if it should be found that the mental steamship of the female can, after all, store enough fuel to cross the ocean of reasoning, it would give woman the inestimable benefit of correcting the possible errors into which a professed enemy of her sex has fallen. It would demonstrate that, like Mr. Darwin's pea-hen, women have remained inferior to their mates, not because of natural defect, but by reason of external circumstances. A just trial is the whole demand of the reform philosophy.

In the Royal Society, many years ago, it is said Charles II asked an explanation of the fact that a fish in water had no weight; that water plus a fish was no heavier than water without a fish. The wise gentlemen of the Royal Society (presumably males of large bulk) were much agitated over the problem, and gave many scientific reasons for the remarkable phenomenon. It was a wiser man (though not of so scientific a turn of mind) who, instead of giving his reasons why the fish had no weight in its own element, tried the experiment and found, to the surprise of the scientific gentlemen, that a practical test was of more value than any quantity of learned but ill-founded speculation. Perhaps it will not be out of place, by way of parallel to Miss Hardaker's triumphant demonstration of "the reason why," to cite the testimony of a prominent instructor, whose evidence tends to show that her scientific impossibility may be affected by some elements which she has not considered. "So far as my observation and experience go," says President Magill, of Swarthmore College (a gentleman who for ten years has been the instructor of about three hundred students of both sexes), "there is absolutely no difference in the average intellectual capacity of the sexes, under the same training and external influences. The valedictorians of our classes have been almost equally divided between the sexes, with a slight and accidental preponderance in favor of the young women."

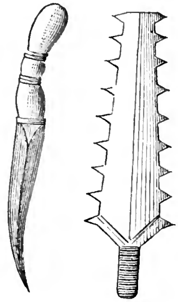
THE GENESIS OF THE SWORD.*

THE idea of employing weapons for assault or defense was a logical result of the first contests that took place between man and man. In these contests the strongest man with his native weapons—his fists—was unconsciously the father of all arms and all armed strength, for his weaker antagonist would early seek to restore the balance of power between them by the use of some sort of weapon. The shorter-armed man lengthened his striking power by the use of a stick, and found, after a time, the help its leverage and weight afforded him. The first case in which the chance-selected, heavy-ended staff or club showed that weight or hardness had its value, was a first step toward furnishing it with a strong head. Hence the blow of the fist was the forerunner of the crushing weapon. In the same way the pointed stick became the lance or dagger; and the thrown shaft, helped, as knowledge increased, by the bow or "throwing-stick," was the precursor of the dart and arrow. The character of the first weapons was largely determined by the nature of the materials from which they were derived, and their shape partly from this and partly by copying the forms of the weapons possessed by the animals the primitive men slew. Hence arises the general similarity in character and shape of the earliest tools from all parts of the world.

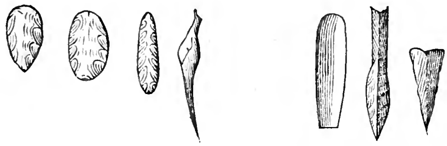
The weapons of animals are piercing, striking, serrated, poisoned, or missile; and weapons made directly from those of some animals were used for similar purposes. Spears and lances are found made from the weapons of the walrus, boar, gnu, rhinoceros, sword-fish, narwhal, and antelope, to be used for piercing, as the animals themselves used them. The serrated bone of the sting-ray furnished both the material and example for many a South-Sea Island spear. The saw-fish's snout has given the natives of New Guinea a ready-made weapon (Fig. 2), and the setting of the shark's teeth in the jaw has suggested their employment in making deadly the edge of a Tahiti sword (Fig. 39). The curved buffalo-horn and the wavy antelope-horn gave the types of the Indian *kandjar* (Fig. 1) and many other Eastern weapons. The hollow poison-fang of the venomous serpent not only gave a lesson to the South American Indians, who use a poison-tipped spear, but indirectly suggested holes for poison in the poisoned arrow-heads, and grooves for the same purpose in the mediæval stiletto. The barbed arrow-head was suggested by the barbed sting of the insect, which stays in the wound it makes; and the Bushman may have learned to half cut off his arrow close to the head, so that it should break off in the wound, from observing how stings thus break off in

* From a paper by C. Cooper King, of the Royal Military College, Sandhurst, in Cassell, Petter, Galpin & Co.'s "Science for All."

the body they have penetrated. Other patterns have been furnished by the stones which the primitive men have had to use for crushing and cutting tools, and have been developed in working them out. Thus we have the axe, spear, lance, or dart, and arrow (Figs. 3, 4), of the palæolithic men, the stabbing dagger made from reindeer-horn (Fig. 6), and the stone lance-heads (Fig. 5) of the cave-men.



In the next stage, that of the "neolithic" men, the tools are a little better finished; the weapons



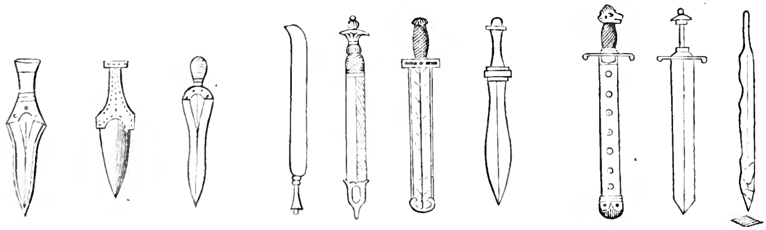
1 2 3 4 5 6 7 8 9

WEAPONS FROM ANIMAL FORMS. PALÆOLITHIC. NEOLITHIC.

cut better, the lance-heads are thinner, sharper, and finer, and provisions for fastening to handles appear (Figs. 7, 8, 9); and the dagger (Figs. 8 and 9) has developed the form from which all the other hand-weapons have come.

The bronze age, having the art of working in a more tractable material, gave an improved weapon. Its dagger is thinner, broader, more pointed, and more dangerous, but yet bears evidence, in peculiarities of shape, that memories of the stone age still survived in the fabricator's mind. The blades are still short, but the weapon is furnished with a handle of wood (Fig. 11) or bronze (Fig. 10) or ivory (Fig. 12), often richly decorated and quite small. The ancient nations furnish us longer daggers, or swords of bronze, of various patterns, as the Egyptian (Fig. 13), Assyrian (Fig. 14), and Grecian (Figs. 15, 16) swords.

The earlier swords were used exclusively for stabbing. Adaptation to cutting was begun after bronze was introduced, and was de-



10 11 12 13 14 15 16 17 18 19

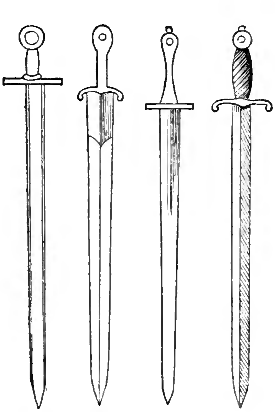
IRISH. ENGLISH. EGYPTIAN. ASSYRIAN. GRECIAN. ROMAN.

veloped as the art was learned of forging iron and steel into weapons. The first iron swords copied the shape of their bronze ancestors, and, while they were longer and more formidable stabbing instruments than those, were not much better for cutting. They were broad, two-

edged, and in time pointed. Finally, the Romans made the *gladius*—sharp, of highly-tempered steel, and strongly piercing—the first real sword (Figs. 17, 18, 19), of which only five specimens are now known to exist.

The well-tempered and well-made Saxon sword was the property only of those who had the rank of thane. As a rule, it was a straight, cut-and-thrust blade, with a double edge and a broad point, though other shapes have been found.

Of the three ways in which a sword may be used for cutting, that called chopping, in which the work is done with the shoulder and forearm and little play of the wrist, and the blow comes down straight with a whack, is of the most value against body-armor. The mediæval swords, therefore, were stout, straight, and wide (Figs. 20 to 23), and adapted to that kind of work. The hands being clad in mail, no attempt was made to protect them, and the hilts were plain and simple, except that a groove was sometimes made in the side of the blade to diminish the weight of metal without causing a loss of strength. The character of the sword varied little except as to the fashions suggested by fancy, till armor was done away with about 1600. Then, the change



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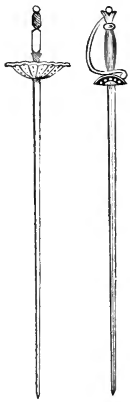
MEDIÆVAL.

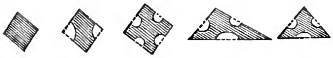


24 25

RAPIERS.

of the sword into the single-edged weapon or the rapier-blade began to become common. While rapiers with flat or very slightly triangular blades, and often immoderately long, were used in France, Spain, and Italy in the sixteenth century, the full development of this form of arm (Figs. 24, 25) took place in the seventeenth and eighteenth centuries. The blades were narrow, the hilts had merely a single narrow guard for the back of the hand, with a broad base to protect the fingers in thrusting, and the rhomboidal or triangular section of the blade was altered, lightened, and stiffened by grooving (as in the group of figures, 26).

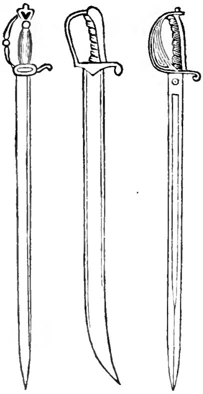
The fighting-swords of the latter part of the eighteenth and former part of the nineteenth centuries (Fig. 27) were not very good, either as rapiers or sabers, and marked a period of transition to one



26

SECTIONS OF SWORD-BLADES.

almost of decadence. The cavalry-swords of the early part of the present century were clumsy and unscientific. With great width of blade and a tendency to increase the width toward the point (Fig. 28), they were not intended for cutting weapons, and were almost useless as thrusting ones. The idea that weight at the sword-end was valuable in enhancing the force of the cut was faulty in theory and practice, and was rather a retrogression to the principle of the axe than an advance in the true method of construction of the sword. This has given way to the modern sword, which combines within itself all the powers of which the weapon is capable, is good as a guard for thrusting and for cutting. Slightly curved, but not so much as to impede its pointing power, nor so wide as to be too heavy, stiffened by grooves so as to be capable of use as a rapier, its blade, with an edge on one side along its length, is flattened at the point, where it is ribbed, for strength, into a two-edged sword (Fig. 29). The hilt has a wider guard, and is intermediate between the rapier type and that of the basket form. Adopting the principles that have obtained at various times, it is a good all-round weapon in skillful hands.



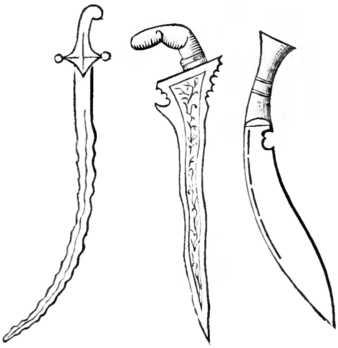
27 28 29

While Western nations have thus tended to adopt a straight blade, Eastern races have almost without exception preferred a curved sword. By reason both of their physical peculiarities and of the lighter character of the armor they wear, they have been accustomed to administer cutting blows with their weapons rather than the straight, downright strokes that are adapted to Western strength and armor, and a curved edge is more suitable for cutting blows. The hilt of the Eastern sword is small, and the boss, or pommel, at the end of the hilt is large, so as to prevent the sword from slipping when the drawing cut is made. The Asiatic swords exhibit, moreover, greater divergencies of type than the Western swords. Some, like the Persian cimeters (Fig. 30), and the Malay creeses (Fig. 31), are often wavy, sometimes resembling the conventional tongue of fire (flamboyant), forms which may be due to the influence of the priests of the fire or the sun, or may be copied from the curvature and ornamentation of the antelope-horn dagger. The Albanian sword has the edge thrown forward by the

slight forward curvature of the blade, a feature which is heightened in the Goorkha knife, the owner of which, it is said, can decapitate an ox with one blow of it (Fig. 32). Some of the Eastern swords, as those of the Chinese, the Bashi-Bazouk or Circassian dagger, with its blade resembling the Roman gladius, and the Mahratta sword, are straight, like the Western weapons.

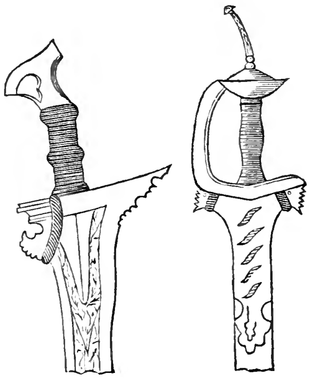
The ornamentation of all these weapons is very frequently only the survival of the methods by which the blades were fixed to their hilts, which was generally by thongs or rivets. Thus the Malay creese (Fig. 33) and the tulwar (Fig. 34) are made clearly to indicate the way in which the blade was originally lashed with cords to the hilt.

The sword does not rank so highly with savage nations as the spear



30 31 32

Asiatic Curved Swords.



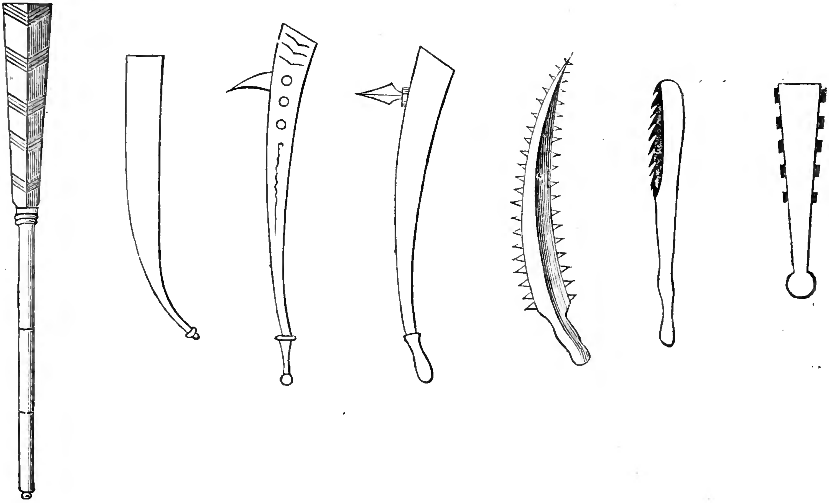
33 34

Survivals of Methods of Attachment.

or club, and belongs to a higher civilization than that which is satisfied with hand-to-hand weapons of stone. But the development of the club into the sword is easily traceable, though the ultimate resultant is far inferior to the metal blades of even the bronze age. Figs. 35 to 41 show the successive steps. The New Zealand club (Fig. 35); the Indian collaree-stick (Fig. 36), often used as a missile; the Iroquois club (Figs. 37, 38), rendered good for piercing or cutting as well by a deer-horn point at first, and by an iron blade later on; the Marquesas (Fig. 39) or Tahiti cutting instrument, armed with sharks' teeth; the Esquimau or Australian sword (Fig. 40), in which strips of meteoric iron, obsidian, or glass are inserted in a cleft in the side of a stick, and fastened by cement; and, lastly, the Mexican maquahuilt (Fig. 41), or wooden sword, armed with sharp, razor-like flakes of obsidian, are the progressive steps of savage life toward the sword. The last-mentioned weapon was deadly enough to be ranked with its iron compeer, for it is said to have been capable of cutting off a limb. In this respect it is the highest type of a sword of other materials than metal.

Of all weapons, the sword has held throughout historic time the

highest place. Its use implied the personal courage of the individual at close quarters. The arrow might slay at a distance, and be discharged by a coward. The spear, again, if long enough and deftly



35 36 37 38 39 40 41

Development of the Sword among Savages.

held, could kill without risk to the holder thereof, unless the adversary were similarly armed. But the sword meant personal conflict, where the victory was not always to the strong. Rightly it is the sign of might and governance, for it implies both the will and the power to execute the behests of its holder. It is one of the insignia of authority, because it is the sign of courage and skill.

ON THE DIFFUSION OF ODORS.

By R. C. RUTHERFORD.

THE following paragraph is similar to others I have occasionally seen going the rounds of the papers for the last twenty-five or thirty years:

> It is said that a grain of musk is capable of perfuming for several years a chamber twelve feet square without sustaining any sensible diminution of its volume or its weight. But such a chamber contains 2,985,984 cubic inches, and each cubic inch contains 1,000 cubic tenths of inches, making in all nearly three billions of tenths of an inch. Now, it is probable, indeed almost certain, that each such cubic tenth of an inch of the air of the room contains one or more of the particles of the musk, and that this air has been changed many thousands of times. Imagination recoils before computation of the number of the particles thus diffused and expended. Yet have they all together no appreciable weight and magnitude.—*Moseley's Illustrations of Science.*

More than thirty-six years ago I announced, in some lectures I was then engaged in delivering, that there were some facts in the phenomena of odors and the sense of smell that were incompatible with the effluvia or diffusion-of-particles theory; and I suggested an explanation based on the idea of a vibration or wave-motion, and an "odoriferous ether" analogous to, if not identical with, that of the luminiferous ether.

In the year 1863, in a letter to Professor Tyndall, I submitted the thought to him. After quoting some passages from his book, "Heat a Mode of Motion," upon the subject of odors, I wrote as follows: "I would respectfully ask if, in the consideration of, or in the course of, experiments upon this subject, it has ever occurred to you that *odor* might be as essentially a "mode of motion" as heat, light, or sound? . . . The seemingly unlimited generation of odoriferous particles (?) by certain substances, without sensible diminution of bulk or weight, first led to the conception that, however copiously odoriferous particles of matter were disseminated through the atmosphere, the odorous property itself was as purely a specific variety of motion as the undulations of the luminiferous ether. That this *must* be the explanation of the action of the odor-generating force for a part of its route to the human sensorium seems to be incontrovertible, for it is hardly conceivable that the material particles should actually penetrate the membrane and force their way, as moving bodies, through the pulpy tissue of the nerves to the seat of sensation; but that through that portion of their career, at least, their power is propagated by wave-like motions analogous to those of heat and sound."

Professor Tyndall did me the honor to answer my letter, but not to indorse my view, except in a very faint and qualified manner. Nevertheless, reflection and added experience have only gone to confirm me in the correctness of it, and I venture to predict that before many years it will be as much an accepted fact of science as the undulatory, luminiferous-ether theory now is.

In the case given above the entire space of the chamber is thoroughly impregnated with the perfume as much as if it were an absolute solid of odor. And yet these "particles," so profusely diffused through the room, are wafted away, and their places supplied by new emissions from the *undiminished* "grain," "many thousands of times" every year without appreciable "sensible diminution of its volume or weight," or pungency. This is an obvious impossibility upon any theory of molecular or atomic diffusion. The assumption of immense diffusibility and vastness of inter-particular spaces would only enhance the difficulty, for the odor spans the spaces—is as absolutely continuous as if the particles were in actual contact. That is, in the given space, the chamber, anywhere within the limits of the odor, there is no place where it is not. This *actio in distans* implies ethereal motion —vibration—between the particles.

According to this view the odoriferous bodies, or their molecules, have no more to do (in the sense of physical impact) in producing the sensation of smell than a luminous body—a candle or the sun—has to do (by impact) with the sensation of light. There is corporeal impact or touch in neither case. Of course, with each molecule as a center of activity, the effect will be more pronounced at the immediate surface (as with all radiant energies) than at any distance. And, undoubtedly, particles of disintegrating, odorous matter are often brought in contact with the Schneiderian membrane; but the sensation of that impact, if there be any, would be of touch, not of smell, as surely as that, from that point of contact to the sensorium, the effect or influence is conveyed by a vibration—a wave-motion in the "fluid" of the nerve-duct—as the undulations of the luminiferous ether are propagated along the course of the optic nerve to the seat of sensation, where they are translated into light and color. But, if, for any portion of the distance between the internal sense and the fragrant body, the odor, like light, is but a motion, it is safe to assume it for all. The analogy of this mode of odors to that of light and sound is something in its favor.

COLOR-BLINDNESS AND COLOR-PERCEPTION.*

By SWAN M. BURNETT, M.D.

TO physiologists that part of the function of vision which is concerned in the perception of colors has always been one of great interest, but it was not until the genius of Thomas Young offered them his theory of vision that they had anything like a plausible working hypothesis. This theory, as elaborated and promulgated by Professor Helmholtz, has until very recently been the one most relied upon in explanation of all the phenomena of colored vision. It is, however, a pure hypothesis, since not one of its fundamental principles is a demonstrated or even a demonstrable fact. By a process of deductive reasoning, and most probably with little, if any, experimentation—for it is said that Young prided himself on being independent of the necessity of experiment—the vivid imagination of this original mind seized upon an hypothesis which seemed to satisfy the demands of an acceptable theory, in so far as it accounted for all or nearly all of the observed phenomena. At that time, however, and even when Helmholtz resurrected and revivified the theory, the question of color-blindness had not been investigated to the extent it has within the past ten years, and most physiologists rested content with the belief that at last the true theory of colors had been found.

* A paper read before the Philosophical Society of Washington, December 18, 1880.

Such, however, is no longer the case, and there are many who are not almost but quite persuaded that the true theory of vision is one of the questions to be solved by the coming physiologist. This theory of Young-Helmholtz, as it is called, demands three primary or fundamental colors, by the admixture of which all other colors are produced. These colors are supposed, by Helmholtz, to be red, green, and violet. All other colors and shades are made from the proper mixture of two or more of these colors. White is the sensation produced by the proper mingling of all three sensations; black is the absence of sensation. Corresponding to these three primary sensations there are in the retina, or terminal expansion of the optic nerve, three distinct sets of nerves which respond to the wave-lengths of the luminiferous ether which physically represent these colors.

This is all very simple and extremely plausible, but certain phenomena of vision make it necessary to so modify this simplicity as to spoil its beauty and give an elasticity to the theory which can not be gratifying to the student of exact science. It becomes necessary to suppose, for instance, that the nerve-fiber which responds to red is also affected, in a less degree, by the green waves, and in a still less degree by the violet; and the green waves, while principally affecting the green fibers, affect also the red and violet; and the violet waves influence the red and green fibers, though in a much less degree than they do the violet. In this theory gray is but a white of diminished intensity.

Color-blindness is explained in keeping with this theory as follows: Any one or all three of the color-fibers may be wanting, or lacking in functional activity. Consequently there may be red-, green-, or violet-blindness, or there may be total color-blindness. Since, however, it is supposed that each one of the color-fibers is affected (though in a less degree) by both other colors as well as by its own peculiar color, there must be a sensation produced by each color, though it will be of lessened intensity in the case of the lacking color, and that sensation must be other than that of the color belonging to the missing fiber. Under these circumstances, even a saturated primary color would not, when its fiber was missing, appear black, though it would appear darker than to one with normal color-perception. To a red-blind person, a spectral red, for example, while appearing a color much less luminous than is usual, would not be black; and, if a solar spectrum were presented to such a color-blind individual, it need not appear shortened at the red end. If the green fiber is the lacking one, green will not appear as black; but when of a certain shade will appear as gray, and for the following reason: White is the product of the sum of all the sensations which the mind is capable of perceiving through the eye. When the eye is normal, we have it when all three of the fibers are affected in about the same degree, and in the color-blind when the two remaining fibers are thus affected. Any color, therefore, which contains, be-

sides green, a certain proportion of the other colors (red and violet)—as certain shades of what we call green do—will cause, when presented to such a green-blind individual, the sensation of white of diminished intensity. When the solar spectrum is placed before him, there should be a gray or neutral band at the line which divides the two colors which are unmistakably distinguishable; and, in the green-blind, it is nearer the red end of the spectrum than in the red-blind.

When the violet is the lacking fiber, we have phenomena analogous to those where the red fiber is missing, though, of course, there are differences in details.

In accordance with this theory, therefore, there can be no color-blindness, in the strict acceptation of the term, except when all the color-fibers are lacking; because all colors produce an impression of some kind, though it may not be the one experienced by those of normal color-perception. There is, however, a marked confusion of the various colors, and by the special character of this confusion one kind of color-blindness is differentiated from another.

In making an examination for the diagnosis of color-blindness, nomenclature, or the naming of the colors which are presented to the person to be examined, is entirely discarded. It has been found that an individual may be able to name the several colors correctly, and yet make mistakes when called upon to match them; and, on the other hand, he may not be able to name a single color correctly, and yet make no serious mistakes in "matching." The method of comparison is therefore the only one which should be adopted in making examinations for color-blindness.

The method of Professor Holmgren, which is the simplest and, on the whole, the most convenient, consists in placing on a table before the examinee a large assortment of skeins of colored worsteds. A "sample" skein of light-green is laid to one side, and the individual is told to select from the pile all the skeins which are of the same color—lighter or darker. If he places by the sample a shade of any other color but green, he is color-blind. This examination, however, does not fix the particular color to which he is blind, and, in order to find the color which is lacking in his chromatic scale, a purple or rose-colored skein is laid aside as a sample and the confusions he makes here are supposed to fix the diagnosis. If he matches the purple with blue and violet or one of them, he is *red-blind*. If, however, he selects the greens and grays, he is *green-blind*. *Violet-blindness* (which is very rare) is recognized by a confusion of red, purple, and orange in the test with the purple skein.

Another plan for employing the comparative method is to have two solar spectra, one above the other, the upper of which is movable. A colored band is isolated in the fixed spectrum, and the upper spectrum is moved until what is supposed to be the same color is immediately above it. Or, the isolated band may be matched with a skein of

colored wool. Of course, the same mistakes will be made here as in the preceding method.

Another method of examination rests on the phenomena of what are called contrast colors. When a white surface is illuminated simultaneously by a red and a white light—as by two lamps, for example, before one of which a red glass is held—an object, a pencil, for instance, held midway between the two will cast two shadows, one from the red light and another from the white light. To one of normal color-perception, one of these shadows (that cast by the white light) will be red, while the other (that cast by the red light) will be green; to any one blind for either one of these colors, there will be no difference in the color of the shadows. If rings cut from black or gray paper are laid upon red or green paper and the whole is covered with tissue-paper, the rings will have a reddish tinge if the ground is green, and green if the ground is red. If, however, the individual is blind to either of these colors, no such difference will be noted; and, if letters cut from black or gray paper are used instead of rings, they can not be distinguished when laid on the colored ground and covered with the tissue-paper.

Another method is to make letters of certain colors on different colored grounds—shades of red letters, for instance, on a green ground. When these are of the requisite tints, the color-blind person is not able to distinguish them.

There are other methods, but they are all modifications to a greater or less extent of the foregoing, and any one who is color-blind to any considerable degree can be detected by any one, or at least by any two, of the methods indicated.

There is another theory of colors brought forward within the last few years by Professor Hering, of Prague, which is adhered to by many physiologists, and is a vigorous rival of the Young-Helmholtz theory. Professor Hering assumes that there are three chemical visual substances in the retina, which he calls the *black-white*, the *red-green*, and the *blue-yellow*. Light acts upon these substances by what he calls assimilation (A), and dissimilation (D). When light acts in a dissimilating or decomposing manner on the black-white substance, the sensation of white is produced; when there is an assimilation or regeneration of this substance, the sensation is black. Hering is by no means certain which are the A- and which the D-colors, but he is disposed to regard red as the dissimilating color of the red-green substance, and green the assimilating color. Blue, he thinks, causes dissimilation of the blue-yellow substance, while its regeneration is caused by yellow. All colors, he supposes, act in a dissimilating manner on the black-white substance—that is, they produce the sensation of white in addition to their own peculiar color. They act, however, in varying degrees of intensity, yellow acting with the greatest power, the strength of action diminishing toward the two ends of the spectrum.

In accordance with this theory, there are, therefore, four fundamental colors instead of three (excluding black and white), namely: red, green, yellow and blue, and they are supposed to be produced as follows: Red is the product of the dissimilation of the red-green substance, green is the result of its assimilation; blue is the result of the dissimilation of the blue-yellow, and yellow of its assimilation. When the A- and D-action on the red-green and blue-yellow substance are equal there is no color sensation, but only the D-action of these colors on the black-white substance, that is white. Simultaneous A- and D-action on the black-white substance, however, is not attended by abolition of sensation, but by the sensation of gray.

It will be seen from this that, in the Hering theory, what were before considered as *complementary* colors are *antagonistic* and tend to neutralize each other. It will be remembered that those colors have been called complementary which, when mixed together, would produce white (we speak now of spectral colors). This was explained by the Young-Helmholtz theory on the principle of combination; it is accounted for by the Hering theory on the principle of subtraction. When red and green, for instance, form white on being mixed, the white is not produced by the sum of the sensations of red and green, but the red and green, being antagonistic, neutralize each other, and there only remains the D-action of both colors on the black-white substance—that is, white.

As in the Young-Helmholtz theory, the other colors, aside from the primary, are the results of mixed sensations.

Color-blindness, in accordance with this theory, is of two forms. In one, both color substances are wanting, and there only remains the black-white substance to be acted on by light (achromatopsia). In the other form, one of the two color-substances is lacking and only the two colors of the remaining color-substance are distinguishable (dichromatopsia). If the red-green substance is lacking, there will be red-green blindness or blue-yellow vision; if the blue-yellow substance is the missing one, there will be blue-yellow blindness, or red-green vision.

To satisfactorily account for some of the phenomena of color-blindness, however, it becomes necessary to suppose that, when one color-substance is wanting, the light rays which act specifically on that substance produce an A- or D-action on the remaining color-substance. In red-green blindness, for example, red, yellow, and green act in a dissimilating manner on the remaining blue-yellow substance, giving rise to the sensation of yellow, while blue alone acts in an assimilating manner. The most strongly dissimilating color will be yellow, while the others will be more or less varying in their action. In the case of blue-yellow blindness, red, yellow, and blue are the dissimilating colors and green the assimilating color. It will be readily understood, when we have this state of affairs, that in the dichromatrope, where

the A- and D-action of the one remaining color-substance are equal, gray will be the result, because, as we have before remarked, where two colors neutralize each other there still remains the action of both on the black-white substance, which will give rise to the sensation of gray or white of diminished intensity. But the same colors will not appear gray to all color-blind persons, for the reason that the same colors do not act in every case with the same intensity of dissimilation and assimilation. In most individuals it is the purple and the blue-green which give rise to the impression of gray.

A spectrum should, in accordance with this theory, appear in only two colors to the color-blind, and may or may not be shortened according as the dissimilating power of the two remaining colors is intense or very feeble. The only colors, of course, which such a color-blind person can with certainty distinguish are the two belonging to the one remaining color-substance, blue and yellow, for instance, when there is red-green blindness, and red and green when there is blue-yellow blindness. It is not to be understood, however, that such an individual can never correctly distinguish other colors. Most frequently he can, but there is always a liability to confusion, often of the most astonishing character ; and, moreover, the distinctions are made, not by the sense of color, but by some other characteristic, different degrees of luminosity, most commonly.

The evidences which the phenomena of color-blindness have brought against the three-fiber theory of Young-Helmholtz are :

1. That the red-blind can not distinguish perfectly the greens and violets, nor the green-blind the reds and violets ; yellow and blue being the only colors about which they make no mistakes.

2. Even in a spectrum which is very much shortened the red-blind finds the brightest place, not in the bluish-green, as we should expect, but in the yellow, as in the normal eye.

3. This theory can not satisfactorily explain the extreme shortening of the spectrum, extending, as it sometimes does, into the orange, and even into the yellow.

4. The line of demarkation in the spectrum is sharply at the blue, all to the left almost always appearing of one color, and all to the right of another, there being no lines of division between blue and violet, nor between the red and yellow and the yellow and green.

5. The gray or neutral band is far from being invariably present, and when it is it is often, in the red-blind, in the position it should be in the green-blind, and *vice versa* (Mauthner).

Against the Hering theory the following objections have been advanced :

1. There is no reason for supposing that red and green and blue and yellow are opposing colors. They are all active in their specific line, and even Hering has not been able to determine which possesses the A-action and which the D-action.

2. The simple colors are not complementary, as Hering asserts; blue-green, and not green, is the complementary color of red, and violet-blue, and not blue, is the complementary color of yellow. The simple colors can not, therefore, be considered as antagonistic.

3. The white, which comes from the union of two of Hering's antagonistic colors, is not the result of subtraction, but of addition, as is shown when, with a double spectroscope, a saturated violet being made to cover a yellow, a white is produced which is manifestly more intense than the yellow, while another yellow of the same intensity as the violet added to the yellow does not produce a yellow intenser than the yellow resulting from the first experiment.

4. White is not a direct independent sensation; it is absent in the spectrum where, in red-blindness or violet-blindness, the specific color is absent (Donders).

From the foregoing, and from a study of the phenomena as presented by a number of color-blind persons, two important facts are forced upon the unbiased observer: 1. That we have not yet arrived at any fixed laws governing the phenomena; that all cases can not be classed as distinctly red, green, or violet blindness, though it seems probable that all might be classed under the heads of red-green and blue-yellow blindness. 2. That neither of the two prominent hypotheses fills the demands of an acceptable theory, inasmuch as both fail to account consistently for all the phenomena.

It seems to us that, in the consideration of the subject of color-blindness hitherto, too much stress has been laid on the part which the retina plays in color-perception. There are three distinct agents at work in the perception of color. The impression is first made on the retina; this is carried thence by means of the optic nerve to the center in the brain which presides over the function of vision, and it is there converted into a sensation. Let any one of these agents become incapacitated, from any cause, for properly carrying on its function, and there must be a perversion or absence of sensation. In certain affections of the retina and optic nerve we have instances of color-blindness from deranged or abolished functional activity of the first two agents, and in some forms of toxic action, particularly alcoholic poisoning, we have in all probability examples of the cerebral form of color-blindness. The supposed color-fibers or color-substances may be in a perfect condition and acted upon in a perfectly normal manner by light, but the optic nerve may be incapacitated by some change in its molecular structure from carrying all of the impressions correctly to the brain-center, and, even should all the separate impressions arrive there, the cerebral center itself may not be in condition to convert them into the proper sensation. The conducting power of the nerve, or the converting power of the cerebral center, may be but slightly deranged or totally deficient for some color or colors, and so the phenomena presented by two cases falling under the same category would be very different;

and, when we consider the infinite degrees of incapacity that may exist for all the different colors, we can readily understand the infinite variation in the mistakes of the color-blind, and the impossibility of laying down exact rules for diagnosis.

It is my belief that a large number, perhaps a majority, of the cases of congenital color-blindness have not their seat in the retina at all, but are cerebral in their character. In other words, I believe that in these cases the brain-center of vision has not the power to differentiate the various impressions it receives. This opinion will seem the more plausible when we remember that the sense of sight is a developed or educated one. Though we have received from our ancestors the potentiality of vision, every child that is born must learn to see for itself. Without here entering into a discussion of the question of the development of the color-sense, which has received much attention at the hands of Mr. Gladstone, Magnus, and others, it is safe to assume, with our knowledge of analogous matters, that the differentiation of colors is a power partly inherited and partly developed in the individual; and, moreover, we should expect to find this power, which is undoubtedly cerebral in its character, most strongly developed where the faculty was most used. And so we do find it. Women, who are much more concerned than men in the selection and comparison of colors, are rarely affected with color-blindness; and we all know how much quicker the feminine eye is in detecting slight differences in shades of color than is that of men who are not color-blind. In those cases of color-blindness which, for the sake of distinction, we shall call central, we believe that the brain-center of vision has not been developed to its full or at least to its ordinary power for discriminating between the impressions corresponding to the different colors. The retina may be capable of properly responding to these various impressions, and the optic nerve may carry them as separate impressions to the brain-center; but this has not the power of converting them into individual sensations.

From what has already been said, it is evident that neither of the two at present prominent theories satisfactorily accounts for all the phenomena of color-blindness. Moreover, it seems to me, the true theory of colors when found will be simple; and the laws governing the sense of vision will be found to bear some analogy to those governing the other senses—at least, I do not believe it will be found necessary to invent new processes and new reactions of tissues to agents affecting the economy. The true theory, I believe, will be found to lie in the direction pointed out by the recent researches on the physical reaction of certain simple substances to the undulations of the luminiferous ether. This reaction may be in its restricted sense chemical, purely physical, or chemico-physical; but it will be due to the changes in the molecular structure of simple substances, caused by the action of the ether. In other words, *the variation in the sensation*

produced will have its basis, not in complexity of tissue, but in the varying action of the affecting agent.

Without entering into a discussion of the question in detail, I would say that it seems probable that the optic nerve is merely a highly organized nerve of common sensation. In some of the lower forms of animal life light is perceived over the whole cutaneous or external surface, as shown by the action of the animals when exposed to its influence. Furthermore, it is now a generally admitted fact that heat and light are due to vibrations of the same ether, differing only in their wave-lengths. The effect of both heat and light is to produce molecular change. When heat produces a sensation through the cutaneous nerves, it is most probable that it does it by means of a molecular change in the terminal filaments of these nerves which is communicated to the brain-center through the nerves, probably also by a rapidly progressive change in their molecular structure. The nerves of common sensation, however, do not seem to possess the power to differentiate variations in wave-lengths—they take cognizance only of the varying intensity of the vibratory motion; that is to say, they distinguish quantities rather than qualities. It would, however, be doing no violence to known facts to suppose that a high specialization would enable these nerves to carry as distinct impressions the changes wrought by the separate wave-lengths. In fact, it is highly probable that they do so, but the cerebral centers in which they terminate have not been educated to the point of making distinctions between these separate impressions and fixing them as individual sensations.

In framing a theory of color-perception on the basis we have indicated, we would suppose the retina to be a body whose molecular structure is such that it will respond with promptness to all or nearly all the wave-lengths of perceptible light. This molecular change produced in the retina is carried by the optic nerve to the center of vision in the brain, and is there converted into a sensation. This is, to some extent, going back to the original theory of Newton, who, in speaking of the action of light upon the retina, considered that "the rays impinging upon the ends of the optic nerve excite vibrations which run through the optic nerve to the sensorium. Here they are supposed to affect the sense with various colors according to their nature and bigness."

The chief objection to this hypothesis, advanced by Young, was that the frequency of these vibrations must be dependent upon the constitution of the substance of the retina, and it was almost impossible that every sensitive point should have an infinite number of different particles to respond to this infinite number of vibrations. He therefore supposed the number to be limited to three which corresponded to red, green, and violet.

It will be seen that the difference in the different theories of colors lies in the supposed reaction of the retina to light. After the impres-

sion has passed beyond the retina, there is no special or important difference in the views as to the final conversion into a sensation. The objections to these two hypotheses we have already stated. The acceptance of such an hypothesis as we propose, however, does not involve the necessity of inventing new laws, or of creating new issues, but only applies known laws and analogous reactions of other substances to the elucidation of the phenomena observed. We know that there are membranes which respond with promptness to any number of simple aërial vibrations at the same time, and recent discoveries have shown that there are substances which, when in proper condition, thus respond to wave-lengths of light. Silenium, when in a crystalline condition, alters its molecular condition (as manifested by its varying resistance to the passage of the electric current), not only when acted on by light of varying intensity, but also by the different wave-lengths. If, then, we suppose the retina to be a substance of this nature, but responding more promptly, and in a more delicate manner, than any other known substance to the wave-lengths of light, we have a basis for a theory of vision which is extremely simple in its nature, and founded on known physical laws.

We will not here enter upon a detailed application of this theory to the elucidation of all the phenomena of colored vision, but will simply mention a few points in connection with color-blindness. One general principle may be laid down which will cover all cases of retinal color-blindness as distinguished from cerebral or central, and that is, that in these cases the molecular structure of the retina is so altered as to allow it to respond feebly or not at all to light rays of certain wave-lengths. We know, for example, that silenium must be in a crystalline state—that is, its molecular structure must be in a certain definite condition—before it can respond in such a delicate manner to variation in the intensity of the light-waves ; and we know that there are certain wave-lengths of the ether—the ultra-red and the ultra-violet—which call forth no reaction on the part of the retinal substance. It would, therefore, be a highly justifiable supposition that a slight alteration in the molecular structure of the retina would render it incapable of being affected by certain wave-lengths to which it, when in a normal condition, readily responds. This incapability may be partial or complete as regards any particular wave-lengths. In some instances of color-blindness, for example, the spectrum is shortened at the red end even under the most intense illumination, while in others there is a shortening only when the illumination is feeble—becoming of normal length when the intensity of the illumination is increased—showing, in the latter case, that the reaction to the red rays is still present when they are of sufficient intensity.

When we come to cerebral color-blindness, which is, according to my view, the most common, the explanation is still simple. In this instance we have only to suppose the cerebral center of vision incapa-

ble of distinguishing between the impressions of wave-lengths which lie relatively near together as regards their vibration numbers. It will be noticed, as an important fact, that there is confusion only of those colors which lie toward the same end of the spectrum. Red and green, for instance, are the colors which are most commonly undistinguishable; blue and yellow less commonly; but no instance is on record in which red and blue, or green and yellow, were constantly confounded. It seems from the examinations thus far made that the color-blind make, as a rule, distinctions between only two classes of color-sensations. A most intelligent color-blind man, whom I recently examined with the spectrum, saw it only as two colors—the line of demarkation being sharply at the blue-green junction, all to the right was blue, all to the left was what he called red. He could distinguish no line of separation between the red, green, and yellow, and the maximum of intensity was at the yellow, as is the case with normal eyes. As Mauthner says, there are no fixed rules which serve us for a diagnosis between red- and green-blindness. The two colors are confused, but how are we to know which is the one correctly perceived? The individual who is found to be green-blind by one method of examination is often found to be red-blind by another, and in some cases to have a shortening of the red end of the spectrum. Moreover, the red-blind can not unerringly pick out the greens, nor the green-blind the reds.

If, as we believe, a large number, perhaps a majority of the cases of congenital color-blindness are cerebral rather than retinal, and due more to a want of education of the color-sense than to any anatomical defect, a plan for the diminution or eradication of color-blindness would be by no means chimerical. The fact that women are less frequently color-blind than men we consider most probably due to the circumstance that their faculty for color is in more active and constant use, and for this reason has become more highly developed, and has been transmitted as a sexual peculiarity from mother to daughter. It seems, therefore, quite reasonable to suppose that if boys could have their color-sense educated to the same extent as girls, and the process were continued through a number of generations, the defect of color-blindness would in course of time disappear, except as a rare anomaly.

STALLO'S "CONCEPTS OF MODERN PHYSICS." *

By W. D. LE SUEUR.

"IT is generally agreed," says Mr. Stallo, "that thought in its most comprehensive sense is the establishment or recognition of relations between phenomena." All perception is of difference; and two

* From a criticism of "The Concepts and Theories of Modern Physics," in the "Canadian Monthly."

objects, therefore, are the smallest number requisite to constitute consciousness. On the other hand, objects are *conceived* as identical by an attention to their points of agreement; though *conception* may also be regarded as *perception* applied to a group of objects, so as to bring before the mind its class characteristics; the word well expressing the gathering into one of the several qualities or properties by which the group is distinguished from other groups. Conception is, therefore, the source of *ideas*, and the word *concept* expresses the union effected in the mind of those attributes or properties under which a given object is at any moment recognized. In other words, it is "the complement of properties characteristic of a particular class." If the class be a very special one the concept will apply to but few individuals; but the complement of properties which it will connote will be a very comprehensive one. If, on the other hand, the class be a very wide or general one, the concept will apply to a much larger number of individuals, but it will comprehend fewer attributes or properties. As application widens, meaning narrows; until from an *infima species*, or in English a group of the most special kind, we rise to a *summum genus*, or a class in which only such properties remain as are absolutely essential to thought. The process by which this is done is the process of abstraction, which consists in dismissing from consideration all properties not essential to the particular class which we may wish to form. Objects are known, it is further to be remarked, "only through their relations to other objects," and each individual object only "as a complex of such relations." No operation of thought, however, "involves the entire complement of the known or knowable properties (or relations) of a given object. In mechanics a body is considered simply as a mass of determinate weight or volume, without reference to its other physical or chemical properties"; and, in like manner, every other department of knowledge only takes account of that aspect of the object which it is necessary for the purpose in hand to study. The mind can not completely represent to itself at any one time all the properties or relations of an object; nor is it necessary that it should do so, as they can not possibly all be relevant to the same intellectual operation. Our thoughts of things are thus *symbolical*, because what is present to the mind at a given moment is not the object in the totality of its relations, but a symbol framed for the occasion, and embracing just those relations under which the object is to be considered. A concept in which all the relations of an object should be embraced is an obvious impossibility. We can not stand all round a thing all at once; we must choose our side, or, in other words, fix upon our point of view.

The above line of thought will be familiar to all students of philosophy, and particularly to those acquainted with the writings of Mr. Herbert Spencer. For some reason or other, however, Mr. Stallo abstains, not only here but generally throughout his book, from any

mention of the relation of his philosophical views to those of other writers. He does not give us his bearings, so to speak, but leaves us to discover them for ourselves. We can not think this policy a good one. To the general reader it is not helpful, as it may lead him to form an exaggerated idea of the originality of the views contained in the volume—a result, we are sure, at which the author would not consciously aim. Some special illustrations of what we are now remarking upon may present themselves before we close.

"All metaphysical or ontological speculation is based upon a disregard of some or all of the truths above set forth. Metaphysical thinking is an attempt to deduce the true nature of things from our concepts of them." The last sentence presents us with a definition of admirable terseness and force, stating as it does the whole case against metaphysics in a dozen words. For purposes of thought we analyze and abstract; but, not content with deriving from these operations the logical aid they are calculated to afford, we fly off to the conclusion that what we have done in the realm of thought holds good outside of thought or absolutely. To apply this to the matter in hand: where the "mechanical theory of the universe" asserts mass and motion to be the "absolutely real and indestructible elements of all physical existence," it overlooks the fact that mass and motion by themselves are really elements of nothing but thought, and are simply a kind of mental residuum after all the more special properties of objects have, by successively wider generalizations (as before explained), been mentally abstracted. As our author puts it: "They are ultimate products of generalization, the intellectual vanishing-points of the lines of abstraction which proceed from the *infimæ species* of sensible experience. Matter is the *summum genus* of the classification of bodies on the basis of their physical and chemical properties. Of this concept, *matter*, mass and motion are the inseparable constituents. The mechanical theory, therefore, takes not only the ideal concept matter, but its two inseparable constituent attributes, and assumes each of them to be a distinct and real entity." Mr. Stallo sees in this a survival of mediæval realism; but it is really nothing else than the opinion of the multitude, now and in all ages, elevated to the rank of a philosophical doctrine. Men in general are materialists who temper their materialism to themselves by a supplementary belief in spiritual existences.

Not only is the mind prone to believe that its concepts are truly representative of external realities, but it readily assumes also that the order of succession in the world of thought must be the order of development in the external world. The effect of the latter illusion is completely to invert the order of reality. "The *summa genera* of abstraction—the highest concepts—are deemed the most, and the data of sensible experience the least, real of all forms of existence." Because we arrive at the concept matter by leaving out of consideration all the properties that differentiate one form of matter from another,

and because matter thus divested of its special properties forms a kind of rock-bed of thought, we conclude that similarly undifferentiated matter must form the rock-bed, or, to vary the figure, the original raw material, of the objective universe. But manifestly, in the scale of reality, the highest place must be given to things as they are, to individual objects with their full complement of properties, and successively lower places to such objects robbed by abstraction of one after another of their essential attributes. When we come to *matter*, we have just enough left to think about and no more. The logical faculty, however, goes further, and performs the tremendous feat of sundering the elements, *mass* and *force*, the conjunction of which alone renders matter a possible object of thought; whence arise endless discussions as to whether motion is a function of matter, or matter a function of motion. The first opinion is known as the *mechanical* or *corpuscular* theory of matter, and the latter as the *dynamical*. The true answer to these intellectual puzzles is that we have no business dealing with the mere elements of thought as if they were elements of things, and that so long as we do we shall only succeed in landing ourselves in in what Mr. Spencer calls "alternative impossibilities of thought."

The notion of the inertia of matter is similarly a product of abstraction, and by no means a representation of fact. Our author's explanation (page 163) is as follows: "When a body is considered by itself—conceptually detached from the relations which give rise to its attributes—it is, indeed, inert, and all its action comes from without. But this isolated instance of a body is a pure fiction of the intellect. Bodies exist solely in virtue of their relations; their reality lies in their mutual action. Inert matter, in the sense of the mechanical theory, is as unknown to experience as it is inconceivable in thought. Every particle of matter of which we have any knowledge attracts every other particle in conformity with the laws of gravitation; and every material element exerts chemical, electrical, and other force upon other elements which, in respect of such force, are its correlates. A body can not, indeed, move itself; but this is true for the same reason that it can not exist in and by itself. The very presence of a body in space and time, as well as its motion, implies interaction with other bodies, and therefore, *actio in distans;* consequently, all attempts to reduce gravitation or chemical action to mere impact are aimless and absurd.

This whole passage is so completely on the lines of the Positive Philosophy, that to us it seems singular that the author could have penned it without making some reference to the precisely similar views of Auguste Comte, views which the scientific world in general has largely disregarded or ignored. "Did the material molecules," says Comte ("Philosophie Positive," vol. i, p. 550), "present to our observation no other property than weight, that would suffice to prevent any physicist from regarding them as essentially passive. It

would be of no avail to argue that, even in the possession of weight, they were entirely passive, inasmuch as they simply yielded to the attraction of the globe. Were this correct, the difficulty would only be shifted; the earth as a whole would then be credited with an activity denied to separated portions of it. It is, however, evident that, in its fall toward the center of the earth, the falling body is just as active as the earth itself, since it is proved that each molecule of the body in question attracts an equivalent portion of the earth quite as much as it is itself attracted, though, owing to the enormous preponderance of the earth's attraction, its action alone is perceptible. Finally, in regard to a host of other phenomena of equal universality, thermal, electric, and chemical, matter plainly presents a very varied spontaneous activity of which it is impossible for us henceforth to regard it as destitute. . . . It is beyond all question that the purely passive state in which bodies are conceived to be when studied from the point of view of abstract mechanics becomes under the physical point of view a complete absurdity." Nearly sixty years have elapsed since this was written; and yet, as Mr. Stallo's book proves, there is a necessity for repeating and re-enforcing it to-day. The same may be said of the doctrine that all our knowledge of objective reality depends upon the establishment and recognition of relations; or, in other words, that the properties of things by which we know them are their relations to other things. This doctrine lies at the very foundation, not only of the Positive Philosophy, but of all true philosophy, and yet, according to the statement of our author, it has been "almost wholly ignored by men of science, as well as by metaphysicians, who constantly put forward the view that whatever is real must exist absolutely": or, in other words, that nothing which does not exist absolutely can be real. Hence have arisen the endless discussions as to absolute motion and rest. That motion could be real, and yet only relative, has seemed, even to such eminent thinkers as Newton, Leibnitz, and Descartes, wholly impossible; yet far from there being any impossibility in the matter, the truth is that it is only relative motion that can have to our apprehension the character of reality. Absolute motion could in no way be distinguished from absolute rest.

THE TREE THAT BEARS QUININE.

By O. R. BACHELER, M. D.

THE introduction of cinchona-culture into India was commenced in 1862. The rapid destruction of the cinchona-tree in South America, owing to the reckless method of gathering the bark, and the consequent high price of quinine in a country where that drug holds

so important a rank, led the Government of India to try the experiment of introducing the tree into the waste mountainous regions of that country. Difficulties almost insurmountable were at first presented in obtaining young plants and seeds from the cinchona regions of the Andes, on account of the obstacles thrown in the way by the different South American governments. Several years passed before a sufficient number of plants could be secured for purposes of experiment.

Experimental gardens were opened on the Nilgiri Mountains of Southern India, the Himalayas on the north of Bengal, the hills of Assam and the Northwest Provinces, and on the highlands of Burmah. With the exception of the Nilgiris and Himalayas, these localities were found to be unfavorable.

At Darjeeling in the Himalayas, four hundred miles north of Calcutta, near which the cinchona-gardens are located, I gathered the following particulars of the introduction and culture of the cinchona-tree, and the manufacture and use of its alkaloids :

1. The soil, climate, and temperature of the cinchona regions of the Andes were carefully noted. Gneiss and mica schist in a somewhat loose and decomposed state, with a covering of vegetable mold, at such an altitude as would secure a moist temperature with the least possible variability, were the observed conditions, and these were sought for in the Himalayas. Gneiss and mica schist compose the prevailing formation throughout the Himalayan range, except its snow-capped summits, which are granite. To find the proper altitude was a more difficult matter. The higher and lower were at first tried, but it was found that an elevation of from four to five thousand feet above the sea-level afforded the most favorable conditions.

The soil is, as far as possible, identical with that of the Andes. The eastern terminus of the Himalayan range, being nearest to the sea, and in the range of the southeast monsoon, which on land is southwest, is constantly shrouded in mist, so much so that the rays of the sun are seldom clear. The eternal snows and glaciers are here not more than fifty miles from the burning plains of Bengal, the highest peak, the second in the world, being more than twenty-eight thousand feet above sea-level. The rain-fall is more than double that of the plains, the last ten years showing an average of one hundred and thirteen inches per year. A remarkably uniform temperature is thus secured, the extremes being 34° and 90°, while the ordinary summer range is between 60° and 70°, and the winter between 45° and 55°.

Several varieties of the cinchona have been tried. Some have failed entirely, while the *C. saccirubra* and *C. calisaya* prove the most hardy. The former of these has proved by far the most productive, and is now much more generally cultivated.

2. The seeds ripen at the commencement of the dry season succeeding the rains, i. e., in October and November. After being gathered they are spread out in shallow boxes to dry. It is estimated that an

ounce of seeds may produce from twenty to twenty-five thousand plants. When thoroughly dried they are sown in beds, and when well started the young plants are transferred to nursery-beds protected from sun and rain by light thatched roofs. When from eight months to a year old, or about twelve inches high, they are ready to be planted out, the thatch-covering having been removed for a fortnight or so to harden them. Propagation by cuttings is practiced to some extent, and succeeds well. The plants are about six feet apart, and an acre of ground may produce a thousand or more trees.

Where vegetation is so rapid and profuse as in India, constant weeding is necessary, and, until the trees are sufficiently large to shade the ground, one or two hoeings a year are highly beneficial. The following may be considered as a fair representation of the rapidity of growth:

At	four	years of	age,	9	inches	girth,	9	feet height.
"	six	"	"	13	"	"	17	" "
"	ten	"	"	21	"	"	30	" "
"	twelve	"	"	28	"	"	39	" "

At first, a very successful method was introduced for securing the bark without injury to the tree. Commencing with trees about eight years old, a strip of bark an inch and a half wide was taken from the trunk, extending from the lower limbs to the roots. Leaving a strip of equal width, an inch and a half, another was taken, and so on quite round the tree, thus removing one half and leaving one half intact. The whole trunk was then covered with moss, carefully bound on, so as to exclude the light and air. In from ten to eighteen months the bark would be found to be completely renewed without detriment to the growth of the tree. The new bark thus formed was found to be thicker and richer in quinine than the natural growth. This process could be repeated at intervals of from a year to a year and a half for an indefinite period. This method is still followed in the Nilgiris, while in the Himalayas it has failed on account of the ants, which penetrate the moss and destroy the exposed wood. In the Himalayas two methods are now practiced. By the first the trees are felled and the bark carefully peeled from the trunk and branches. The stumps are allowed to remain, and from the sprouts that spring up two of the most thrifty are preserved for future trees, while the rest are cut away. This is called coppicing. By the second method the tree is uprooted, and the bark removed from the trunk, branches, and roots. The ground is then replanted with seedlings. Time must show which of these methods will prove the most profitable.

The bark, on being removed from the trees, is placed in open sheds near at hand to dry, that the first process of drying may be in the open air and in the shade. When dried as much as possible without artificial heat it is carried to the dry-house, a close brick building, where the process is completed with the aid of slow charcoal-fires.

The drying is thus accomplished, at the lowest possible temperature, without detriment to its chemical qualities. After this it may be stored without danger of deterioration.

3. The medicinal alkaloids contained in the bark are quinine, cinchonidine, quinidine, and cinchonine. Quinine has long been regarded as by far the most important of these, being the great specific for malarious fevers. The price of bark in the market has consequently varied with the amount of quinine it was found to contain, with very little reference to the other alkaloids. Careful experiments have shown that all these alkaloids possess a very high medicinal value, but little if at all inferior to quinine.

Malarious fevers, prevailing so extensively throughout India, and especially among the lower classes, the high price of quinine has rendered it absolutely prohibitory to the masses. Consequently, the Government has turned its attention to the production of an article that should contain, as far as possible, all the febrifuge qualities of quinine, at a rate so moderate as to come within the reach of all. This benevolent object has been fairly reached in the production of what is known as amorphous quinine, or cinchona alkaloid, which sells at about fifty cents per ounce, while quinine is held at from three to five dollars per ounce. The products of the government cinchona-gardens are largely employed in the manufacture of this drug.

The method of preparation is extremely simple. The bark, roughly pulverized, is macerated in cold water acidulated with sulphuric acid, until its properties are quite exhausted. Its resulting liquor is precipitated by a caustic alkali potash. The precipitate is then dried, pulverized, and sealed in tin boxes of a pound each. The powder is of a dull whitish color, very light, almost insoluble in water, but dissolves readily in acidulated water. At the time of issuing the last report, one hundred and forty thousand ounces of this febrifuge were being produced from the Himalaya gardens.

4. At an early period extensive experiments were instituted to ascertain the relative curative value of the different alkaloids. One commission, consisting of sixteen prominent medical officers, reported as follows:

Treated by cinchonine,	410	cases.	Cured,	400,	failed,	10.
" " cinchonidine,	359	"	"	346,	"	13.
" " quinidine,	376	"	"	365,	"	11.

The experiment was then varied, in which the alkaloids were pitted against quinine. The number of fever-cases treated was 2,472, with 2,445 cures and 27 failures. The ratio of failure per 1,000 was as follows:

Treated by quinine	ratio of	failure	7·092
" " quinidine	"	"	5·024
" " chinchonidine	"	"	9·926
" " cinchonine	"	"	23·255

These results, corroborated as they are by many subsequent experiments, in various parts of India, conclusively show that all the alkaloids of cinchona possess a nearly equal curative value, and hence the conclusion is that all combined possess a value very little if at all inferior to quinine. The doses are about the same. Cinchona alkaloid is now largely used throughout the country, with a proportionate reduction in the demand for quinine.

SKETCH OF SIR JOHN LUBBOCK, Bart., M. P.

SIR JOHN LUBBOCK is one of that class of men of whom each age can present only a few brilliant specimens, who are at home, and masters, in pursuits of the most diversified character. He is almost equally distinguished as a banker and man of business, as a zoölogist, ethnologist, and archæologist, and as a publicist and parliamentarian. He stands in the front rank among bankers, while he occupies a prominent position among naturalists, and "is a standing proof that an industrious man of active mind may at once be diligent in business while serving science." "His name," says one of his most appreciative biographers, "is equally familiar to the ethnologists and entomologists of New York or of Moscow, in the counting-houses where the world's business is settled, and among the Maidstone Liberals, who every four years temporarily lose their voices with crying, 'Sir John and liberty!' Most curious of all, the cause of this reputation in one circle is little known to those in the other two. The Kentish rustics may know that the 'Squire' is fond of looking at queer things, and the bankers may have sometimes listened to him at the Royal Institution or in Parliament; but each set of men judge their many-sided friend by their own standard, and in each department he has rendered services which ought to command the respect in which he is indubitably held."

Sir John Lubbock derives his versatility in a very large measure by inheritance. His father, Sir John William Lubbock—the third baronet of that name—was head of the banking-house to which the son has succeeded, and earned a more enduring fame as an astronomical and mathematical writer. He was for twelve years Treasurer and Vice-President of the Royal Society, and was the author of works on "The Lunar Theory," "Perturbation of the Planets," "Researches on the Tides," the "Theory of Probabilities," and other publications, which are still quoted as authorities. His treatise on "Probabilities" anticipated that of Quetelet by several years, and, being published anonymously, was for some time ascribed to De Morgan.

The present baronet, the subject of this sketch, was born in Lon-

don, on the 30th of April, 1834. His early education was received in a private school kept by Mr. Waring ; at a later period he was sent to Eton College, where he had the Earl of Dalkeith, Lord Grey de Wilton, Mr. Lefevre, and Mr. Chitty, Q. C., for fellow-pupils. He was withdrawn from school when fourteen years old without being allowed to enter the university, and put into the bank ; for his father's partners had been taken suddenly ill, and it was deemed important that he should be prepared to assume control of the establishment as soon as possible in case death should take away its heads. His attention was here directed to quite different objects from those in which he had been interested, but he did justice to their demands, and exerted himself to become a complete man of business, with a success to which his subsequent accomplishments as a banker and the mark he has left in English methods of business bear ample testimony. He did not suffer this, however, to divert him from his former pursuits. He passed his leisure at the family seat of High Elms, near Farnborough, in Kent, "a goodly mansion in the midst of an estate of fourteen hundred acres, which had been purchased by his grandfather." Here he continued his studies in natural history, and made it an object to supplement and extend that education only the foundations of which are laid at school and college.

The banking-house of which Sir John Lubbock is the head—that of Robarts, Lubbock & Co., has been in existence since 1750, has always stood high, and has not decreased in stability during the administration of its present chief. Under that administration it has promoted a reform in the methods of transacting business throughout the kingdom that has greatly facilitated and expedited it, by securing the extension of the clearing-house system of London to the country banks.

The clearing-house has long been a most useful institution among the London bankers for collecting the checks paid in by their customers with greater facility than by sending round to the various banks and getting the money over the counter, and, in their turn, having to pay to the messengers of other bankers the charges drawn on them. In the clearing-house building as many desks are arranged as there are bankers connected with the institution, each of which is allotted to a particular banker. A clerk, going with a number of checks upon some or all the bankers, puts those which are drawn upon each on his desk. At the same time all the other banks holding checks upon his bank place them upon his desk. When the day's business is completed, only the balances shown upon posting the checks *pro* and *con* have to be paid over, and this is done through drafts upon a special account in the Bank of England. Mr. Babbage had called attention to the proportion of transactions of bankers that passed through the clearing-house to those that did not. Acting upon the suggestion given by Mr. Babbage, Sir John, taking an amount of $115,000,000 that passed through the hands of his house during the last few days of 1864, analyzed the

respective items of clearing-checks, bills, bank-notes, and coin, and found that out of each million more than $700,000 passed through the clearing-house. Such a measure of the convenience secured by the system was evidence enough that its extension was desirable. Under the old system of settling country accounts, a country bank taking in the course of the day two hundred checks, drawn on perhaps one hundred bankers scattered all over the kingdom, had to write one hundred separate letters and dispatch them by post to as many different points. Under the new system, the checks are all sent to London, grouped and classified as are the city checks in the city clearing-house, and sent in batches to their destinations, with a great saving of labor.

To Sir John Lubbock is also due the introduction of a method of examination for clerks of bankers and joint-stock companies conducted by the City of London College, in the same manner as the examinations instituted by the Government under the Civil Service Commissioners. He is also Honorary Secretary to the London Association of Bankers, and in that capacity, besides keeping the records of the meetings of the association, acting as secretary of all committees, controlling the internal arrangements of the Clearing-House, etc., he has the duty of representing the bankers of London on questions relating to Government in Parliament, and, indeed, whenever any intermediate agent between banking circles and the officers of Government is needed. When the Institute of Bankers, now numbering more than two thousand members, was formed, he was unanimously chosen its president. He has contributed many valuable papers to financial literature, and was a member of the International Coinage Commission.

The proper performance of these multifarious duties would seem not to leave time for the successful pursuit of any other occupations, but Sir John Lubbock has been able to give them due attention and, in addition, besides doing good service to his country in Parliament, to become a distinguished investigator and experimenter, and an authority in more than one branch of science. Science was one of the earliest of Sir John Lubbock's pursuits, and it was one of those that he has most constantly followed up. He knew practically nothing of banking till he was fourteen years old, while his name was not on the rolls of Parliament till he was a man of thirty-six. But he was a naturalist in his very childhood. His taste in this direction was carefully nurtured by his father, who was accordingly very glad when Mr. Darwin settled as his near neighbor at Down. From that day forward he was a pupil of that master, and became one of his most ardent disciples. His methods of investigation are very similar to those of Mr. Darwin, and consist largely of the minute, accurate observation of small things. His researches in zoölogy have been chiefly devoted to the development, habits, and structure of the lower animals, chiefly of insects and crustacea, in which he has made numerous discoveries that are recorded in various scientific journals and in the "Transactions"

of the Royal, Linnæan, and other learned societies. Relative to these subjects he has published an elaborate treatise on one of the obscure groups of insects, entitled a "Monograph of the Thysanura and Collembola" (Royal Society, 1873), and works of a more popular character on the "Origin and Metamorphoses of Insects" and "Wild Flowers considered in Relation to Insects," in the latter of which he considers the agency of insects in the fertilization of flowers by carrying pollen from flower to flower while in search of food, and the adaptation of the flowers to the function of dusting the insects that visit them with their pollen and to the reception of the pollen of other flowers from them. His most recent researches, carried on with the aid of members of his family, have been devoted to the observation of the habits of insects, particularly of wasps, bees, and ants, which have been attended with important discoveries. He has given particular attention to the study of the mental faculties of insects, whether those creatures have any, and to what extent they may be developed, and has made numerous interesting communications on the subject to the British Association and the Royal Institution, which have been extensively published, even in miscellaneous journals, and generally read; and in connection with this branch he was able to interest the British Association with the life-history of a pet wasp which he kept, to such an extent that its death in the following year was considered worthy of notice in a special paragraph in "Nature." Among the consequences of these publications have been the direction of a greater degree of attention to the biological history of the orders that form the subjects of them, and a higher appreciation of the study of little things.

Sir John Lubbock also became an active and eminent student of archæology. He examined the shell-mounds, or kitchen-middens, on the coast of Denmark, to which attention had originally been called by Steenstrup and other Danish antiquaries, and was the first to make English readers acquainted with those rude relics of the ancient Scandinavian savages. He also studied the gravels of the Somme from Amiens to the sea, in search of prehistoric remains, and explored the bone-caves of Dordogne and the lake-dwellings of Switzerland, and examined the archæological collections in numerous public and private museums. These researches formed the subjects of various memoirs in the "Natural History Review" and other publications, and were finally collected, with many additions, and published under the title of "Prehistoric Times as illustrated by Ancient Remains and the Manners and Customs of Modern Savages," in a work which has passed through five editions. His readings in the literature relating to modern savage life led him to a consideration of the origin of civilization and of the manner in which customs, once all but universal in the infancy of the human race, became altered or narrowed down to the few rude tribes who may now alone possess them. These inquiries were originally

given to the Royal Institution in the spring of 1868, and were afterward greatly enlarged and published in a work, 'The Origin of Civilization and the Primitive Condition of Man," which has passed through five editions, and, like his former work on prehistoric man, has been translated into the French, German, Italian, Danish, Russian, Hungarian, Dutch, Swedish, and other languages. It has also gone through two American editions, and has given rise to considerable controversy which has been called forth by the antagonism of some of its views to the prepossessions of a large proportion of its readers. It must have cost the author an enormous amount of labor, and is, aside from the theories it enunciates, a most serviceable work of reference, offering a nearly exhaustive array of facts which it would be impossible for any student to obtain for himself, drawn from a mass of authorities the mere list of which would fill a considerable space. In this work the Darwinian doctrine is applied in tracing the development of the social and mental condition of savages, their arts, their system of marriage and of relationship, their religions, languages, moral character, and laws. It sustains the belief that "the law of humanity is not degeneracy, but progression; not the falling away from a primitive state of perfection, but the gradual amelioration and advance toward a higher and better condition." To be more particular, the author maintains the conclusions that "existing savages are not the descendants of civilized ancestors; that the primitive condition of man was one of utter barbarism; and that from this condition several races have independently raised themselves." This work was one of the first attempts to treat the origin of civilization on a rational and philosophic basis, and has been pronounced "the completest summary of barbaric life that we possess."

These books form, however, but a small part of Sir John Lubbock's scientific writings, which include besides numerous papers in the transactions of learned societies, and in the scientific and antiquarian journals, the list of which is constantly growing, and the editing from the original manuscript of the treatise of the nonagenarian Svend Nilsson on "The Stone Age of Sweden."

The labors of Sir John Lubbock in behalf of the preservation of the ancient monuments of Great Britain and Ireland may be considered in connection with his scientific work, although they have been carried on chiefly in Parliament, and under the form of appeals to the public. They have found shape in the well-known Ancient Monuments Bill, which passed a second reading three times, but was finally lost in the House of Lords. This bill was based upon the principle "that, if the owner of one of these ancient monuments wishes to destroy it, he should be required, before doing so, to give the nation the option of purchase at a fair price." For this purpose, it proposed to create a body of commissioners especially charged with the protection of the ancient monuments, and so commended itself to all persons in-

terested in the subject that every archæological society in the kingdom petitioned for its passage. It was, however, strongly opposed by other interests, with arguments of the most puerile character, such, for instance, as that the people who erected the monuments were savages, about whom no one cares or should care; that the monuments themselves are ignoble and destitute of all art and of everything that entitles them to preservation; and that to preserve them was to interfere seriously with the rights of property.

Replying to these objections in 1875, Sir John asked the honorable members of the House of Commons to look at the ancient monuments in their own districts mentioned in his bill, and tell him which of them they would see destroyed without regret. "Was it Silbury Hill, the grandest sepulchral monument, perhaps, in Europe? Was it Avebury, the most remarkable of the so-called Druidical structures? Was it Stonehenge, enigmatical and unique? Was it Arthur's Round Table, or the Rollrich Stones, Kitscoty House, or Wayland Smith's Forge, dear to all readers of Sir Walter Scott?" Then, after referring to similar monuments in Scotland and Ireland, he concluded: "Those monuments have passed through great dangers. They have been spared by Roman soldiers, by Britons, Saxons, Danes, and Normans; they were respected in days of comparative poverty and barbarism; in these days of enlightenment and civilization, of wealth almost beyond the dreams of avarice, they were in danger of being broken up for a profit of a few pounds, or removed because they cumbered the ground. If the House allowed them to be destroyed, they could never be replaced. It was said that the bill would interfere with the rights of property. What rights? The right of destroying interesting national monuments. That was the only right that would be interfered with. It was not incidental to the bill, it was no drawback in the bill, it was the very object of the measure. It was really, however, the rights of destruction, not the rights of possession, which it touched. It was now for the House to determine whether it would exercise on behalf of the nation the right to preserve those monuments; whether it would maintain the right of individuals to destroy, or the right of the nation to preserve." Sir John himself bought two of the sites mentioned in his speech, to save them from threatened destruction: Avebury, whose temple was nearly perfect in the time of Charles II, who visited it, but which was now about to be sold for building-lots after most of its stones had been broken up or carried off; and Silbury Hill, said by "Nature" to be "the grandest tumulus in Great Britain, if not in Europe."

Sir John Lubbock's political career may be said to have begun in 1865, when he stood for a seat in the House of Commons for West Kent, at the request of the Liberal Committee, and was defeated by only fifty votes. In 1868 he was nominated as a Liberal candidate for the representation of the University of London, backed by a committee

composed of such men as Airy, Babbage, Darwin, Huxley, Lyell, Max Müller, Tyndall, and others, but he thought it better to leave the field open to Mr. Lowe, and stood, instead, for West Kent, where he was again defeated. In 1870 he was elected for the borough of Maidstone, and again, in 1874, after a keener contest than the preceding one, but a good-natured one. In 1880 he lost his seat for Maidstone, but was returned a few days afterward by the University of London. In recommending him for this seat a number of gentlemen, among whom were Messrs. Alfred W. Bennett, Grant Duff, Thiselton Dyer, F. W. Farrar, D. D., Dr. Michael Foster, H. E. Roscoe, and Dr. Samuel Wilks, said that, since he combined in himself eminence in many branches of knowledge and walks of life, he might be said to represent, as few (if any) others could, the different faculties which combined to form the university. He has made his mark in Parliament as an industrious, discriminating, working member, more distinguished, perhaps, for the merit of the measures he has introduced and supported than as a brilliant orator, although he has acquitted himself excellently in the latter capacity, and earned the reputation of a speaker who always has something to say that is well worth hearing, and the faculty of saying it well. The following list of the bills which he has introduced and promoted in their passage through the Houses attest that his labors have been to the purpose, efficient, and successful. The bills are, to use the peculiar phraseology with which their titles are legally expressed, the Apothecaries' Company Medical Act Amendment Bill; the Bank Holiday Bill; the Falsification of Accounts Bill; the Banker's Book Evidence Bill; the College of Surgeons' Medical Act Amendment Bill; the University of London Medical Act Amendment Bill; the Absconding Debtor's Bill; the Factor's Acts Amendment Bill; the Bills of Exchange Bill; the Dental Practitioners' Bill; the Compromise Acts Amendment Bill; and the Ancient Monuments Bill, which was lost in the House of Lords. All of these acts have a practical bearing on every-day life, and show the stand Sir John has taken in Parliament as the elected member for the University of London, and the representative, by an unrecorded vote, of science and the banking interest. The best known of his bills is the Bank Holiday Bill, which has added four new statute holidays to those that were already in existence, with a result that has been in every way satisfactory, both to employers and to the persons in their employ. Speaking of Sir John in connection with the Ancient Monuments Bill, but having this act also in view, "Nature" styles him "a member whose reputation as an archæologist, though great throughout the country, is exceeded by his popularity as the author of the most successful measure of private legislation in modern times—the Bank Holiday Act." Sir John's political career, as a whole, has been that of a consistent Liberal.

As a magistrate and country gentleman, Sir John Lubbock also takes an active part in most of the varied duties incumbent on an

English land-owner. He has contributed to political literature, though not so voluminously as to scientific, and he has taken an active part in measures to promote the extension and improvement of science-teaching in the schools. The amount of work that he has done could have been accomplished at his age only by means of the most indefatigable industry, and the most economical use of time. He has always been an early riser, and contrives, whenever it is possible, to get three or four hours' work in the morning before breakfast. His career is an example of what can be accomplished in a life well spent. No doubt, says a biographer, many adventitious advantages existed in his case, which poorer men do not possess. He had no anxiety as to bread; but, on the other hand, he does as much mechanical work every day as would entitle him to a very fair return for his labors. Moreover, the calls of his public position make inroads on his time, of which the man who is his own master, by reason of his living in the by-ways of the world, has little idea.

Sir John has received the appointment of the crown as a member of the Senate of the University of London, and has been for several years vice-chancellor of the same institution. He has also been a trustee of the British Museum, a member of the Public School Commission, a member of the International Monetary Commission, and a member of the Royal Commission for the Advancement of Science. In literary, scientific, and scholastic honors he is a Doctor of Civil Law of Oxford, an LL. D. of Dublin, a Fellow of the Royal, Linnæan, Geographical, Geological, and Antiquarian Societies; he has been President of the Ethnological Society, of its successor, the Anthropological Institute of Great Britain, Vice-President of the Royal Society, Vice-President and President of the Linnæan Society, the principal English biological society; and Vice-President and President of the British Association, having been selected for the latter office to preside over the last (the jubilee) meeting of the association, at York.

Sir John Lubbock was married in 1856 to Miss Ellen Frances, daughter of the Rev. Peter Hordern, of Chorlton-cum-Hardy, Lancashire, and has a family of three sons and three daughters. Lady Lubbock was a woman of considerable natural ability, and enjoyed the privilege of giving much encouragement and aid to her husband by the interest she took in all his pursuits. Her sympathies were also extended to her husband's friends, who are still able to remember the hospitable reception they used to meet at her hands. She contributed a paper on "The Shell-Mounds of Denmark" to the volume of "Vacation Journals" for 1862–'63. She was a contributor to "Nature" from time to time, and wrote a few articles which appeared in a published form elsewhere. These works, however, "Nature" remarks, "would afford but a poor criterion of all that she has directly and indirectly done toward the advancement of natural science." She died in 1879.

ENTERTAINING VARIETIES.

THE MOUNTAINS OF THE MOON;*

OR,

TRAVELS AND ADVENTURES OF HAKIM BEN SHEYTAN.

TRANSLATED BY F. L. O.

CHAPTER III.

"Whose sàlam hails me? Hath my friend returned?
It is his form, but not his cheerful voice."

SO says the poet; and thou, too, O father of my faith,† wilt find me an altered man, if it be the will of Allah that we shall meet again. Yet not the frost has chilled my heart; not the harmáttan-wind has seared my brow: the gloom that clouds my soul is the gloom of sorrow for the boundless misery of my fellow-creatures—even of my fellow-men. For the habitants of Monghistan are not brutes; nor are they apes,‡ gifted with human skill. No: they are men, degraded by vice and monstrous superstitions, and as a human being I share in their shame, and the weight of their woe oppresses my own heart. May the angel of mercy be their helper!

Beth-Raka is not a large town, and I hoped to reach the opposite hills by sunset; but, before we had made our way to the end of the first street, the smoke began to stifle our breath, and we concluded to make a *détour* to the right and approach the furnace from the north side of the town, where the ground was higher and the air less suffocating. We entered a side-street, and would to Allah the smoke had been dense enough to blind our eyes and save us the distress of beholding such misery! The street forms a hollow way through the hills, and the rocks on both sides are full of caves, most of them widened to a height of eight feet. In and around these caves we saw a swarm of shapes as if the sleepers of a rock-tomb had issued from their gloomy dens—withered forms, bloated or swollen faces, and eyes that were not fit to meet the light of day. We met a half-grown lad with the face of an old man, and laborers that were too infirm to walk erect, and as we proceeded I saw with horror that the condition of these unfortunates was not the result of an exceptional malady, but of

† Addressed to the Mollah of Tripoli. The *pastor fides* of an Arabian mosque styles himself "Guardian of the Faith," and "Gate-keeper of the Peace-house" (Kada'l Beth-Salàm).

‡ "All that day we met neither man nor beast nor ape," says Ibn Koteiba in his chronicle of the Mauritanian campaign. Monkeys, in the opinion of the Arabs, are not beasts, but *Ayd-Kapi's*—a sort of half-men.

their daily habits. The starved-looking children were playing in the street; some, too weak to play, were sitting on the ground, diverting themselves as well as they could; the men were busy at work, as if disease had become their accustomed state, an evil too hopeless to attempt its cure. Unlike the beggars of Soodan, their poor prefer tatters to nudity. Even their little ones were encumbered with unsightly rags, and, strange to say, the poorest people seemed to have the largest number of children. Habit has inured them to the impurities of the atmosphere; they breathe the thickest dust with indifference; yet these same people are afraid of the night-air. After dark the fire of the furnace burns low and the smoke clears away, at the very time when the inhabitants close every aperture of their hovels. Where whole families sleep together (as in the den of Er-Masood) this insane habit can not fail to increase their infirmities. Poverty is by no means the only cause of their sickliness. The only manly-looking men I saw in that town were the hard-working laborers of a smithy, and in the wealthier quarters, where the children are as pretty as our own, their fathers look unsound and peevish, in spite of their great paunches.

The cave-street led steadily up-hill till we reached the top of an eminence, where we stopped and breathed more freely. On the north slope of the hill the wealthier burghers had some well-built log-houses, and right before us was a large stone building with a spacious court, where I saw a number of fat old fellows, all wearing the same kind of cloaks, and all shaved like the sick of a lazar-house. At first I thought that the place was a sort of hospital for the cure of obesity, but I afterward ascertained that it was a *guttle-house*,* a building where numerous dervishes are fattened at the public expense. These holy men consume great quantities of manioc-roots,† which they digest in the interior of the building, where every one of them has a little stall of his own. At daybreak, at sunset, and again at the rise of the moon, they set up a plaintive howl, in order to save their souls from the Great Pitch-Hole, as the Monakees call the vale of Jehannum.‡ They do not perform any kind of useful labor, but, as their howl is supposed to propitiate the wrath of the gods, they are revered as saints, and the people feed them very liberally. They wear a sort of sack-gowns, as tighter garments would be inconvenient; and among those I met at Beth-Raka some were so fat that I could see their cheeks from behind.

In the mean time the sun had gone down, and, as the twilight in

* Fress-Haus (W.).

† The *Jatropha manihot*, a species of esculent tubers, as nutritious as our yams or "sweet-potatoes."

‡ The mythology of the Mohammedans represents the bottomless pit as a desolate valley, swept by harmáttan-winds, and infested with uncouth goblins and swarms of gadflies—a sort of tropical Tartarus.

this country is very short, we feared that we should lose our way in the maze of the suburban roads. The dervishes of the guttle-house seemed disinclined to converse with strangers, and the children at play on the hill were unable to answer our questions; but at last we met a well-dressed old burgher, who gave us all the information we desired. "The road to Kápibad passes through my field," said he, "and if you will follow me I will show you the shortest way. I live at the foot of the hill over yonder, where you see that large mosque of the Tripilates."

"Is not that sect very numerous in this town?" I asked.

"Yes, their buildings occupy all the best sites," said he, "and they have the impudence to call themselves the only true Yeshanees."

"Do you belong to the Thumpers?" I asked.

"The Thumpers," said he, "are nearly as superstitious as the Tripilates. Their teachers walk in darkness. No, I am a *Kabir*, or Senior, of the Grizzlies,* so called because our people follow the rule of the primitive Yeshanees, whose priests were chosen from among the gray-headed and venerable elders of the community.—How do you like this part of our land?" he asked, when we reached the foot of the declivity.

"The hills remind me of the Khundee highlands," said I; "the buildings of Khundistan can not be compared to yours, but the inhabitants seem to be happy in their free wilderness."

"Yes, they have a happy climate," said he, "but they are poor, ignorant wretches, who worship only one God and take a sinful delight in worldly pleasures. They do not know that the welfare of the soul requires the mortification of the body, and that earthly thoughts obstruct the way to heaven."

"Where does all this smoke come from?" I inquired.

"From the mash-house," said he. "We shall pass it before we reach the city gate. The mashers employ a hundred workmen, and it will surprise you to see what quantities of grain pass through their hands."

If the mash-house had been a bakery, its usefulness could have reconciled me to the smoke, for in this quarter of the city, too, the people seemed to be in desperate want of bread, and I asked the Karman to distribute all our provisions to relieve some of the famished children that gathered around us at the street-corners.

Near the gate the road was not paved, and the ground was here covered with mire instead of dust.

"Yes, cities abound with foul odors and all kinds of impurities," remarked the Kabir, "but such evils are outweighed by moral blessings. In this town even the poorest enjoy the advantage of spiritual instruction and edifying sermons."

"A great advantage, indeed," I was going to say, when I stumbled

* Parduscos (R.).

over a big man who was lying prostrate in the middle of the street. A shorter and fatter fellow was sitting near him, but made no attempt to help his comrade, and for good reasons, as it seemed, for, when I tried to assist the prostrate man, he kicked me like a horse, and after a torrent of frightful blasphemies began to pelt us with mud and rubbish.

"Leave them alone!" cried the Karman; "I believe that drunken wretch has hit me with a stone."

But at those words the fat man jumped to his feet and staggered forward as if he were going to follow us. "Do not call a Yeshanee a wretch," he stammered; "that man is fond of mash, but he atones for it on the prayer-day, and in the mosque no one can exceed the frequency and fervor of his groans.—Oh, how Yesha loves a prayerful heart!" he added; when I heard a loud splash, and, looking back, I saw that he, too, had fallen in the mud, and was evidently as drunk as his companion.

"Mash is very cheap in this town," explained the Kabir.

"Not to those poor fellows," said I; "it will cost them their health."

"Yes, but such losses, too, often result in spiritual gain," replied the Kabir. "The body must be humbled, the natural heart must be broken, before the soul can partake of grace. The vilest sinners become the devoutest believers.—Here is the mash-house," said he, as we stopped before a high stone-wall.

The building was shrouded in a cloud of hot vapor that added a lurid glow to the lights that shone through every hole and crack in the wall, and when we reached the gate we could hear the hiss of a mighty furnace, but the flues were so high that the black smoke passed harmless over our heads. Still, the atmosphere within was almost suffocating. The air was thick with steam, made more offensive by the intensity of the same vicious odor we had first noticed in the eastern suburbs. All this smell, filling the air for leagues around, seemed to be diffused from a seething kettle in the background of the building. A multitude of half-naked men ran to and fro with sacks, pots, and buckets, while others were raking the furnace which was going to be covered for the night. Nearer by, and all along the walls, were large heaps of grain, besides apples and other fruits.

"Is this *hábbada* *—a provision store-house?" I inquired.

"No, these things are merely stored here till they are ready to use them," said the Kabir, "and that will be soon enough: every day five hundred horse-loads of grain are here used up in the manufacture of strong drink. They make five kinds of mash, the cheaper sorts cheap enough for the poorest."

These words convinced me of what I had suspected for some time,

* *Ed' abbada*, "by treason," in the original—evidently by the misplacement of a diacritical point.

though my soul shrank from the thought as long as there was a shadow of doubt, namely, that these ship-loads of victuals would all be made into fire-water; mountains of grain and fruit turned into poison, while the streets were full of starving children!

"Do you believe in a god?" I asked the Kabir.

"I do, and in more than one!" was the prompt reply.

"And do you believe the gods will forgive you this shameful waste?"

The Kabir touched my arm. "Do not talk so loud," he whispered. "How can we help it?" said he, in an undertone; "we have tried all kinds of remedies, and they have all failed. How can we prevent the manufacture of mash?"

"Simply enough," I replied; "do not drink it. Does your religion not forbid such an outrage, or does not your conscience prompt you to stop it? Is the way to freedom so far?"*

"We have not been idle, O son of my uncle," said the Kabir; "the evil has been greatly diminished."

"In what way?" I asked.

"Our dervishes," said he, "prohibit the sale of mash on all prayer-days."

"When do they permit it?" I asked.

"Only on six days out of seven," said he.

"But do you not drink mash in your mosques?" asked my guide.

The Kabir gave him an evil look.† "That is a slander," said he. "What they hand around in our mosques has the smell and the appearance of mash, but before we put it to our lips a special miracle turns it into quite a different substance."‡

"Has it a different taste?" I inquired.

The Kabir hesitated. "Unbelievers deny it," said he. "Our doctors claim that it has the same effect on the human body as a similar quantity of ordinary mash; but science, you know, is always forging weapons to destroy the faith." #

The overseer of the mash-house stood near enough to overhear our conversation. He made no remark, but walked up to the furnace and ordered the laborers to quit work. "It is time to close the gate," said he.

We took the hint and left.

"That overseer owns a part of the mash-house," said the Kabir, when we reached the open street. "I wonder if he has heard your remarks?"

* Professor Widerleger understands this as an allusion to the sixteenth chapter of the Syrian Koran, where the drunkard is compared to a slave who can not fly because "the way to his native land is so far."

† Meyad emásseck—a venomous look.

‡ "Por un milagro peculiar se obra una trasustaciacion," (R.).

\# "Dass die Wissenschaft Waffen zur Vernichtung des Glaubens schmiedet," (W.).

"Do you care if he did?" said I.

"Oh, certainly!" whispered the Kabir; "he is a man of wealth, and a prominent member of our mosque."

The Kabir's residence was a long wooden building at the end of a field, with several shade-trees, and some fifty acres of land, devoted to the cultivation of poison-berries.

"If you dislike the smell of fire-water, you had better accept the shelter of my roof," said he, "for all our caravansaries are redolent with the fumes of mash. As for myself, I never touch the stronger sorts, though our doctors prescribe them."

We thanked him for his kindness, but, as the night was clear and pleasant, we asked permission to camp under one of his shade-trees. While the Karman pitched our tent, our host pressed me to inspect the interior of the building.

"Do you know a remedy for the gout?"* he asked as soon as we were alone. "I have tried all sorts of cures, but unsuccessfully."

"Have you ever tried to drink water!" I asked him.

The Kabir sighed. "I thought you were a physician," said he; "is that the only remedy you know? Never mind," he added, when I made no reply, "I suppose there is no help for it. This earth is a vale of tears."

He had lighted a lamp, and I noticed that the background of his room was full of papyrus-rolls, tablets, and other things that bespoke him a man of letters.

"There is one consolation," said he; "the evils of this earth can not deprive us of spiritual enjoyments. Nay, the more the light of earthly pleasure fades, the brighter the joys of a higher world often dawn upon the mind."

A strange smell began to fill the room, and, looking toward the corner where the Kabir was seated upon his divan, I discovered to my dismay that he had lighted a pot with stink-weeds. He invited me to take a seat at his side, but, seeing that I was in need of rest, he kindly permitted me to retire to my tent.

Before we resumed our journey the next morning, we had to replenish our provision-bags, and met a boy who offered to show us the way to the market-place. "It is not far from here," said he, "you can already hear the shouting of the doctors."

Since daybreak we had, indeed, heard the sound of repeated whoops, often accompanied by the tooting of a cow-horn; and when we arrived at the market-place we soon discovered the cause of the noise. In opposite corners of the square two medicine-venders had erected their platforms, and their incessant yells had already attracted large crowds of the natives. One of the doctors had decorated his booth with all sorts of fanciful pictures, and, while he exalted the

* Akdel heshad, the "wine-disease." Either the gout or the stone.

merits of his medicine, the mahudis * blew their horns, while two assistants ran to and fro distributing spoonfuls and handfuls of a blue powder and collecting copper coins. The doctor had the voice of a steer, and I noticed that his sudden whoops † sometimes opened the purse-strings of spectators who had listened with indifference to his quieter remarks.

His rival had no pictures, but talked with astonishing volubility and attracted customers by a very ingenious device. Behind his platform he had made an inclosure with chains and ropes and filled it with a troop of sickly-looking fellows—cripples, lepers, and such like—as he could easily have collected in any back street of the town. Now and then, in the course of his fluent harangue, the doctor would stop and turn toward this cadaverous assembly. "Have you not all derived great benefits from the use of my oil?" he inquired.

"Yes, yes, yes!" the lepers shouted in chorus, whereupon the mahud blew his horn, and the collectors rushed into the crowd to exchange bottles for coin. At times the doctor varied his query: "Is there any disease which my oil will fail to cure?"

"No, no, no!" yelled the chorus, and a shower of coin followed as before. At longer intervals a couple of assistants would bring a large tub from an adjoining building, and, with the appearance of a strenuous effort, lift it up and exchange it for an apparently empty pot upon the stage.

"Another barrelful sold!" then cried the doctor. "By Allah (whose perfection be extolled!), there is no medicine like it! Oh, the wonderful virtues of my oil!" whereupon the mahud blew his horn vigorously till coppers showered in from all sides.

Walking toward the gate, we overtook several men whom I remembered to have seen at the stand of the oil-man.

"What is that oil good for, O friend?" I asked a young fellow who carried a bottle of it in his hand.

He looked at me with surprise. "Did you not hear what the doctor said?" he replied; "it cures all diseases, so it can not fail to be good for something."

"Tell me, O my master," I asked an old burgher, "do you know what that bottle contains?"

"That I can not tell," said he; "but surely it must be a powerful medicine."

"And do you prefer it to the other doctor's powder?" I asked again.

"Judging from its taste, the potency of this oil can not be ex-

* Mahud (pl. mahudim, or mahudis), a town-crier, or news-crier. When Cordova was the capital of Moorish Spain, every market-hall of the vast city had two mahudis, who announced the news twice a day, like our morning and evening papers.

† "Sein plötzliches Gebrüll," (W.).

ceeded," said he; "no powder in the world could be so bitter and disgusting."

"Why did you buy that bottle, O brother of my uncle?" I asked one other man, an old fellow with the long hair of a villager.

"I bought it because I saw all the townsfolk do the same," he replied; "it must surely be good for something. I should have bought a larger bottle," he added, "but the times are very hard. Our fields are suffering from a drought, and on the western border people are dying with hunger."

The appearance of the country seemed to confirm these words. Six miles from Beth-Raka the fields looked as if the samum-wind had scorched the grass; and here and there at the road-side the people had gathered around a singing dervish, praying for rain, as my guide assured me, though he confessed that he could not understand the chants of the singer. Toward noon we passed a mountain that seemed to be a general meeting-place of the dervishes, for high up among the rocks of the summit we could see a large assembly of people, and even at this distance we heard the sound of their chants.

"What are those people doing up there?" I asked a man who had halted his wagon near a point where a by-road led up toward the top of the mountain.

"Praying for rain," said he; "I am going there myself."

"Your horses will have a hard pull before you reach the top," said I, for his wagon was heavily loaded with grain.

"Oh, no," said he; "my servant will take this load to the mash-house at Beth-Raka. The brewers are paying high prices because of the scarcity of grain."

"And what will you do on the hill?" I inquired.

"Sing and pray," said he. "Will you join me and let us ask Allah to deliver us from this famine?"

"No, sir," I replied, "but I wish I could deliver you from that mash-house."

The fellow turned away with an angry look and remarked that I must be a *Murchuk*—a word which they apply to a race of impious savages who refuse to exalt the glory of Allah.

We had now passed the last ridge that divides the plain of Beth-Raka from the valley of Kápibad; and before us, on the heights of the western hills, we saw the towers and gardens of the Monghistan capital. My guide was well acquainted with this part of the country, and when we reached the next hamlet he took me to a caravansary where he had often stopped, and where we intended to clean our garments before proceeding to the capital. But we had hardly entered the gate of the Asmakan,* when the gate-keeper took my guide aside, and, after a few questions, crossed his arms and greeted me after the manner of the Galla highlanders.

* The court-yard where caravans water their camels.

"May Allah bless the day and the hour of your arrival!" said he. "This morning a messenger of the Emir has arrived from Kápibad, and is now awaiting your coming under a tree where all the roads from the east meet near the village gate."

[*To be continued.*]

—— Dorman, in his "Origin of Primitive Superstitions," gives the following on the authority of Schoolcraft: "Sleep is thought by the Algic race to be produced by fairies, the prince of whom is Weeng. The power of this Indian Morpheus is exerted in a peculiar manner and by a novel agency. Weeng seldom acts directly in inducing sleep, but he exercises dominion over hosts of gnome-like beings, who are everywhere present. These beings are invisible. Each one is armed with a tiny club, and when he observes a person sitting or reclining under circumstances favorable to sleep, he nimbly climbs upon his forehead and inflicts a blow. The first blow only creates drowsiness; the second makes the person lethargic, so that he occasionally closes his eyelids; the third produces sound sleep. It is the constant duty of these little emissaries to put every one to sleep whom they encounter—men, women, and children. They hide themselves everywhere, and are ready to fly out and exert their sleep-compelling power, although their peculiar season of action is in the night. They are also alert during the day. While the forms of these gnomes are believed to be those of little or fairy men, the figure of Weeng himself is unknown, and it is not certain that he has ever been seen. Iagoo is said to have seen him sitting upon a branch of a tree. He was in the shape of a giant insect, with many wings upon his back, which made a low, deep, murmuring sound, like distant falling water. Weeng is not only the dispenser of sleep, but it seems he is also the author of dullness. If an orator fails, he is said to be struck by Weeng. If a warrior lingers, he has ventured too near the sleepy god. If children begin to nod or yawn, the Indian mother looks up smilingly and says they have been struck by Weeng, and puts them to bed."

—— In his "Diseases of Memory," Ribot says: "When a child learns to write, according to Lewes, it is impossible for him to use his hand alone; he must also move his tongue, the facial muscles, and perhaps his feet. In time he is able to suppress these useless discharges of nerve-force. And so, when we attempt for the first time any muscular act, we expend a great quantity of superfluous energy which we learn gradually to subdue. By exercise certain movements are fixed, to the exclusion of others."

—— *What is a Cause?*—Kingdon Clifford says that the word represented by "cause" has sixty-four meanings in Plato and forty-eight in Aristotle. He further observes that "these were men who liked to know as near as might be what they meant; but how many meanings the word has had in the writings of the myriads of people who have not tried to know what they meant by it will, I hope, never be counted."

—— *Oxygen and Consciousness.*—Brown-Séquard, according to Dr. Luys, once injected the head of a dog, when separated from the trunk, with defibrinated and oxygenated blood, and at the moment when the injection of this blood had recalled the manifestations of life he called the dog by his name. The eyes of the head thus separated from the trunk turned toward him, as if the voice of the master had still been heard and recognized.

CORRESPONDENCE.

DR. PRIESTLEY.

Messrs. Editors.

CERTAIN facts connected with the life and history of Dr. Priestley came to my knowledge and recollection about the time of the centennial gathering at Northumberland, Pennsylvania. Had it occurred to me sooner, I should have deemed it of sufficient interest to those present, and to the general public, to have communicated these facts; and, even now, it seems desirable to make this record.

When Dr. Priestley's house was attacked by the mob, and he was driven from his home, he fled for his life, and took refuge with my maternal grandfather, Samuel Vaughan, either at his London house (in Mark Lane, or Mincing Lane), or at his country-house in Hackney. For a long time previous to this date he was very intimate in my grandfather's family, where he was received always as a loved and welcome guest. At the time referred to he remained an inmate of the family for a month or more. My mother, who was born in London, in 1766, was living with her parents at the time of the riot. A strong attachment had grown up between her and Dr. Priestley. She looked upon him as a second father; and I well remember, as a boy, the great pleasure with which she dwelt upon the memory of their friendship. While concealed in my grandfather's house Dr. Priestley wrote his celebrated "Appeal." It was dictated by him to my mother, she acting as his amanuensis. The "Appeal" was printed from her manuscript. As a memorial of this event, Dr. Priestley presented to my mother a brooch, made for the purpose. It is a miniature likeness of himself, cut in shell, on a blue background, and mounted in an oval gold frame, with a scroll across it near the bottom, on which is the word "Appeal." This brooch is now in my possession. I held it in my hand at the time of the celebration, regretting that so interesting a relic could not be viewed by those present. Forty years or more have elapsed since my mother's narration of these events, and, as the present account rests entirely upon the memory of my late sister and myself, it is possibly incorrect in some details. The main points, however, may be relied upon, and as proof may be taken the existence of the brooch, bearing on its scroll the word "Appeal."

T. B. MERRICK.

GERMANTOWN, PHILADELPHIA, *February* 24, 1882.

QUACK ADVERTISEMENTS.

Messrs. Editors.

IN the March number of "The Popular Science Monthly" there is an article from the London "Lancet" entitled "Quackery within the Profession," which, though short, is certainly vigorous. The following quotations are pertinent:

"There can not possibly be a 'system' or 'cure' in medicine. There are no rule-of-thumb methods, and no *mysteries* in true science. If we do not know what a remedy is, and how it acts, we have no right, as honest men, to employ it. The time has passed for the working of cures by charms, and the recourse to nostrums. We pander to the credulity of the unskilled community when we show ourselves credulous. . . . From the highest places in society to the lowest ranks of the people, there is just now a grievous readiness to 'believe in' quacks and quackery. . . . There is no system, or cure, or charm, or nostrum, known to the profession."

These words are strong enough, and are properly found within the pages of a magazine devoted to popularizing science—that is, popularizing it in the sense of giving the unprofessional reader the latest teachings of science without the rigorous processes of induction leading to such results.

The aim being, therefore, such a high and laudable one, is it not somewhat inconsistent, to say the least, to find in the same March number advertisements of the following notoriously quack medicines and remedies?—

St. Jacob's Oil, Græffenberg's Vegetable Pills, Voltaic Belts, Parker's Ginger Tonic, Kidney-wort, Mrs. Pinkham's Vegetable Compound, "a positive cure for consumption," and two whole pages devoted, the one to Warner's Safe Kidney and Liver Cure, and the other to Compound Oxygen?

Such advertisements undoubtedly pay well; but should not a *prosperous* magazine like "The Popular Science Monthly," with such lofty pretensions, be above lending itself, even indirectly, to countenancing quackery, or doing anything to increase that "grievous readiness to believe in quacks and quackery" which the writer in the London "Lancet" so much deplores?

Respectfully yours,

CHARLES E. L. B. DAVIS,
Captain of Engineers.

BUFFALO, NEW YORK, *February* 22, 1882.

Captain Davis writes to the editors of the "Monthly," complaining that they do

not also edit the advertisements. We must draw the line somewhere, and we stop at the one hundred and forty-fourth page. We do not think it would be easy to edit the advertisements. If the rule should be, not to publish lies, it would abolish the department, for they are by no means confined to quack medicines. St. Jacob's may lie about his "oil," and Aunty Pinkham about her "compound"; but there is this mitigation in such cases, that everybody knows it. The worst difficulty begins with those advertisements in which truth and falsehood are mixed, for—

"A lie that is half a truth is ever the blackest of lies."

Our correspondent had better address himself to the managers of the advertising department, and convince them that they should not work down to the low standard of the religious and secular press. Meantime we agree not to sandwich advertisements through the text of the "Monthly," as is the custom with some journals.—Editors.

SCIENCE IN THE PUBLIC SCHOOLS.

Messrs. Editors.

I have read with great interest the articles you have recently published, explaining improved methods of teaching various branches of science in public schools.

At the opening of this school last September, we found ourselves with a class of a dozen boys and girls from fourteen to eighteen years of age, who were ready to begin the study of "natural philosophy." I suppose we might have provided those boys and girls with copies of some one of the many text-books which profess to carry students over the entire subject in "fourteen weeks," or some other incredibly short time; we might have set those students to committing and reciting that text, but we didn't.

After some experimental work with improvised apparatus in illustration of the properties of matter, the students provided themselves with copies of Tyndall's "Lessons in Electricity." We chose that branch of physics rather than any other, because the school owned a set of Tyndall's apparatus especially designed to accompany the "Lessons." The class then began a systematic course of experiment, following, in a general way, the order of their book, but making also many other experiments. The students took turns in conducting the work, and all were enthusiastic. Nothing was taken without proof, and, the better to assure myself of the thoroughness of the work, I had them write up from memory weekly reports of the experiments performed. Of course, our work was slow, but I think it was sure, a real scientific spirit manifesting itself in every member of the class. We have now reached a part of the work where a more powerful electrical machine is necessary, and of course we shall get it. I think it is a mistake to begin with the machine. It is too complicated to be easily understood at first, and the result is a lack of clear ideas. The simple experiments recommended by Professor Tyndall are excellent. They lead the student along so gradually and so surely that when he reaches the explanation of the electrical machine, or the Leyden-jar, he finds very little difficulty.

We have in the school other scientific work than that described above; but this is the one subject where we have the best chance to cultivate accuracy and an interest in scientific methods.

Yours, respectfully,
Charles J. Buell,
Principal of Boonville Academy.

Boonville, New York, *February* 18, 1882.

INFLUENCE OF EARTH-WORMS ON PLANTS.

Messrs. Editors.

I notice much discussion concerning the effects of earth-worms upon plants in pots, in regard to their eating the roots of plants, and also the injury their acid excretions may do the plants. Having kept house-plants for many years and in all sorts of vessels, from unglazed earthen pots to glazed delf, and in iron and in tin vessels also, and having had good success without drainage at all, even by having a hole in the vessel, and also having had the earth-worms under consideration, before Mr. Darwin was heard from on the subject, I feel that I may add an item of interest about them. The complaints that I have seen come from florists. Florists, like all other specialists, have notions, and I believe this about earth-worms hurting plants is one. I have found women who, when their house-plants did not thrive, laid it to earth-worms. I do not agree with them nor with the florists, as I do not believe, from nearly twenty years' handling of house-plants, that earth-worms injure pot-plants. I have used all sorts of soil, from good garden to leaf-mold, and have always used well-rotted manure, in which earth-worms abound, to mix with the soil, and, if I can, have had good air, plenty of light, correct temperature, and have watered properly. I have never failed to have a plant thrive, even if the pot was full of worms, and was tin, delf, iron, or unglazed pottery, and I have grown

and had bloom all of the ordinary house-plants, and some that were not common in house-culture.

I have noticed that the worms will, if there is a hole in a pot, and the pot is not often disturbed, crawl out at the hole and lie under the pot, if there is room, and the bottoms of most pots will allow this, and this they will do in all sorts of pots. Plants frequently become diseased from over-watering, its lack, or from other causes, and too often the worm has to take blame for what he is entirely innocent of.

Yours, respectfully,
ADA H. KEPLEY.

EFFINGHAM, ILLINOIS, *February* 20, 1882.

EDITOR'S TABLE.

"*SCIENCE AND CULTURE.*"

THE reception accorded to Professor Huxley's new volume, under the above title, by the leading organs of public opinion, is especially significant at the present time. The book is a collection of addresses, lectures, and essays, which have appeared at intervals during the last seven years, on a considerable variety of subjects, educational, biological, and philosophical. They are all of superior merit—the maturest and most finished of Professor Huxley's literary productions, and are all of popular interest; but the critics do not regard them as having equal claims to their attention. It is the first address, from which the volume takes its name—given at the inauguration of Josiah Mason's college—to which they chiefly devote themselves, and their discussions are noteworthy, as indicating the great change that is going forward in the public mind with regard to the higher relations of science and education.

It is beyond doubt that the most formidable hindrance to the progress of rational education is the idolatry of an antiquated and effete system of study, on the ground that it is pre-eminently and exclusively adapted to the promotion of "culture." It is by association of classical studies with a dignified and venerated ideal of "culture" that they have acquired their superstitious ascendency, and have become the greatest drags we have on real educational progress. Human cultivation is, and always must be, the supreme thing, and it is, therefore, difficult to overestimate the injurious influence of a false ideal of its means and objects.

But the difficulty in this case is increased by the fact that the ideal of culture, which must now be rejected as wholly inadequate, was once true. The old and the still prevalent idea of culture is that which is derived from literary pursuits, and it is limited to certain literary forms, as most perfect for the purpose. Professor Huxley says of the great majority of educated Englishmen that, "in their belief, culture is obtainable only by a liberal education; and a liberal education is synonymous, not merely with education and instruction in literature, but in one particular form of literature, namely, that of Greek and Roman antiquity. They hold that the man who has learned Latin and Greek, however little, is educated, while he who is versed in other branches of knowledge, however deeply, is a more or less respectable specialist, not admissible into the cultured caste."

But the human mind is no longer to be cultivated merely by the forms or the arts of expression. That these are important things, and that in past times they may have been the main things, no one denies; but such an ideal of culture is essentially superficial, and breaks down before the serious intellectual demands of the present time. The mind of our age has passed from the consideration of verbal figments to the laws of reality. The correlative of form is substance, and the correlative of literary form is the substance of thought, and modern science has made this the funda-

mental concernment. There has been not only a change here, but a reversal of the order of importance. The question now is, not of the art of expression in itself, but to what is it subservient. We grow increasingly impatient of the rhetorician. The casket may be elegant, but what does it contain? The husks and shells of expression have had sufficient attention—we have now to deal with the living kernel of truth. The old ideal is discredited by the new developments of knowledge, and the new ideal must contain more substantial elements than that which it supersedes. Under the old ideal of culture, a man may still be grossly ignorant of the things most interesting and now most important to know; but an ideal of cultivation begins to be demanded which does not comport with ignorance. Modern knowledge is the highest and most perfected form of knowledge, and it is no longer possible to maintain that it is not also the best knowledge for that cultivation of mind and character which is the proper object of education. This truth is making its way steadily, and although the traditional ideal of culture is strongly fortified in existing institutions, and maintained by old habits and associations, it is undermined on every side, and is certain to give place to more comprehensive and rational views of what constitutes a properly cultivated man.

The leading criticisms of Professor Huxley's book, as we have said, illustrate this position decisively. They not only show that the question is uppermost and urgent with the thinking classes, but that science has already so clearly established its main positions that the old resistance is futile, and that a revised and enlarged conception of culture has become inevitable. Professor Huxley is even reproached by distinguished literary authorities for not fully perceiving the strength of his own case, and how far science has already pushed its educational conquests. It is even maintained that the scientific spirit and method have so far penetrated and revolutionized the classical system as to have given it a new lease of life; so that it will be conserved in future only by virtue of what it has borrowed from the progressive agency which it has hitherto so desperately resisted. The London "Saturday Review" discourses upon the subject as follows:

Professor Huxley's position as to the claims of the natural sciences on the one hand and the humanities on the other—of the "modern" and the "classical" plan of education, as they are commonly called—is, on the whole, if we rightly collect his meaning, something like this: The mediæval system of European universities, which with more or less minor diversity was in substance the same everywhere, embraced everything which to the best men of its day seemed best worth a man's knowing, and deserves our thanks and praise according to its time and work. But it became stereotyped and inexpansive. It was too narrow to hold the flood of new knowledge and interests let loose upon the world by the revival of classical learning. The Renaissance, in so far as it affected education, was the protest of far-sighted reformers against the bondage of mediævalism. The humanities fought their pitched battle against the scholastic curriculum, and won it. Our present classical education represents the triumph of the *litteræ humaniores* three centuries and a half ago. But the humanities, like the scholastic system before them, have in their turn become stereotyped. Now science has arisen and opened a new world, unfamiliar to the men of classical traditions, and often scorned by them; and science is fighting its way to its proper eminence as Greek did in the days of Erasmus. The leaders of science are the true humanists of our own time, and the old-fashioned humanities must give place to them. Now, if we were prepared to assume, as Professor Huxley to some extent seems tacitly to assume, that classical education had reached its final development, and that nothing more was to come out of scholarship and antiquities than was got out of them by English scholars forty or fifty years ago, we should entirely agree with Professor Huxley's conclusions. But, for our part, we are not prepared to assume anything of the kind. There are matters not adverted to by Professor Huxley, and to which, as they certainly lie outside his business, his attention may naturally have not been directed, which appear to

us necessary to be taken into account before we acquiesce in the view of science and humanism as two litigant parties, or attempt to pass a final judgment upon their alleged strife.

It may seem a strange thing to say, but Professor Huxley has underrated the strength and the victories of science. They are not confined to the bounds of natural history or physics, or to any or every branch of what we call the natural sciences. The modern spirit of science is too mighty and subtile not to penetrate into every region of the field of human knowledge. It is transforming and re-quickening the humanities themselves; and we make bold to say that classical studies, so far from waning before the light of science, are awakening and waxing to a new Renaissance of which not we, but our children and children's children, will see the full splendor. What is it that Sir Josiah Mason's foundation excludes, and in Professor Huxley's judgment rightly, from the benefits and encouragement of his bounty? "Mere literary education and instruction," such mere drilling in language as until a recent date was understood to be the staple of our so-called classical learning. But our universities are now awake to the truth that knowledge of the ancient languages is an instrument, not an end in itself. The end is another kind of knowledge, and knowledge not undeserving to be compared for worth with the knowledge of things and of nature. It is the knowledge of man in the works of his hands and his thought, of the men from whom we inherit our laws, our art, and our civilization; the praise of famous men, and our fathers that begat us. Socrates and Plato, the fathers of philosophy; Pericles, the father of statesmanship; Alexander, the father of conquering civilization; Ulpian and Papinian, the fathers of scientific law; Trajan and the Antonines, of administration and government; Homer, the father of poetry; Phidias and Praxiteles, of sculpture — these last the masters of all followers in their craft unto this day—and Aristotle, the father of science itself; surely of these men and their work we can not know too much, and even a little knowledge of them would be ill exchanged, for a man who does not mean to be a chemist, for a little knowledge of the atomic weights of elements.

But this, some one will say, is not what comes of our so-called classical education; what we get from our classical teachers is only verse-grinding, scraps and odds and ends of half-understood Latin and Greek, and a general contempt for knowledge that is not of Latin and Greek. This has been only too true; but we hope it will not be true much longer. Cambridge, the head and front of the old verbal scholarship, is transforming her classical curriculum. Not through mere linguistic attainments, but through scientific philology, scientific archæology, scientific study of ancient history and philosophy, will henceforth lie the road to her highest honors. We shall no longer have accomplished classical scholars who stand mute before a coin or an inscription, and can not tell a work of the school of Phidias or Praxiteles from a late Asiatic or Roman imitation. Let the teachers of natural science look to it on their side that their own special studies do not degenerate into mere book-work, such barren catalogues of undigested facts and such an empty show of paper knowledge as Professor Huxley lifts up no uncertain voice against. Then, when at last a true and lively knowledge of man and of his history goes hand in hand with a true and lively knowledge of Nature and her works, our schools will produce results worthy of their noble means, and science and culture will be no longer names to bandy in controversy, but firm and inseparable allies. Science has come upon our humanists as from a region of mystery, like the nameless champion of the legend, clad in magical armor and wielding invincible weapons. But the champion is a friend and deliverer; well for them that receive him, and ill for them that in rashness and little faith repel him. But is there not already a working alliance? Are modern philology and archæology "mere literary education and instruction"? We conceive not; and we call Professor Huxley himself to witness. In his Aberdeen address he expresses the wish that there should be a Professorship of Fine Arts in every university, and that its functions should somehow be regularly connected with the arts curriculum. We are happy to think that this is exactly what is being done, or in a fair way to be done, at Cambridge. The study of classical antiquity through classical art is there rapidly becoming a living and working branch of the general classical studies of the university. But this, some will again say, is dreaming of the future. Are we satisfied with the present? Are we content that there should be university dignitaries who do not know one end of the solar spectrum from the other, and bishops who show their competence to criticise biological theories by supposing that the blood-corpuscles are formed by coagulation after death? We answer, unquestionably not. We hold that the elements of natural knowledge should be an integral part of general education. But we would make room for them

—as we have already said on other occasions —not by ceasing to teach the humanities, but by teaching them better.

The criticism of the London "Academy" still further illustrates the advance of rational ideas on this subject:

The address on "Science and Culture," which gives its name to the volume, is a discussion of the place of scientific and of literary training in education. The form in which the question in debate between the advocates of "science" and of "culture" is presented is not which of these two things is the more valuable, but whether the idea of complete culture does not include within itself that of scientific discipline. This way of stating the question brings out clearly the fundamental agreement that there is—if we leave out of account the devotees of "useful knowledge"—between the advocates of the classics and of physical science. For it is seen that the advocates of science admit that every one ought to know something of literature, though they think it possible sufficiently to cultivate the sense of literary form by means of the modern languages alone; while the advocates of the classics, in maintaining that classical studies give the best possible intellectual training, admit that culture is not complete if nothing but the sense for literary form has been cultivated. The questions that are really in debate are, therefore, the subordinate ones—whether, though real intellectual as well as æsthetic education is given by the study of the classics, physical science is not the typical intellectual discipline, for which anything else is an imperfect subsitute; and whether, though some literary culture can be got out of modern books alone, a certain knowledge of the classics is not necessary as a preparation for the the full appreciation of European literature in general. Professor Huxley decides both these questions in favor of the advocates of scientific education. He suggests incidentally that modern men of science have more of the spirit of antiquity than "the modern humanists. . . . We falsely pretend," he says, speaking of the Greeks, "to be the inheritors of their culture, unless we are penetrated, as the best minds among them were, with an unhesitating faith that the free employment of reason, in accordance with scientific method, is the sole method of reaching truth."

He points out, near the end of the essay, that the higher sciences, those that deal with man and society, can only be constructed by the application of the methods of physical science. As regards the literary side of education, he expresses the opinion that "for those who mean to make science their serious occupation; or who intend to follow the profession of medicine; or who have to enter early upon the business of life; . . . classical education is a mistake." It is possible to get sufficient culture out of modern literature —perhaps out of English literature alone.

Something might be said against this last opinion, even by those who agree with Professor Huxley entirely as to the necessity of scientific discipline as part of a complete education. But, granting that knowledge of classical literature is not an essential part of culture, there is still a difficulty about omitting Greek and Latin from education in some cases and not in others. For, if the classical languages are to be taught at all, it is desirable that the study of them should begin at an earlier age than that at which a decided preference either for literature or for science usually manifests itself.

This last remark is very important in its bearing upon the general issue between classical and scientific studies. It is a concession of what we have constantly maintained, that, if the study of Greek and Latin is to be worth anything at all, it must consume a portion of the time devoted to education that is out of all relation to the value of the acquisitions, compared with others that are necessarily excluded. If that time is not given to them, the acquisitions are so worthless that the effort is wasted; but, if the full time is taken by the classical tongues, there is no room left for any fullness or thoroughness of scientific study. Hence the need, as the "Academy" remarks, of beginning so early with the Greek and Latin that the pupil is unable to form an opinion of the uses and value of his studies. But this period of immature judgment is exactly the proper time for the training of the powers of observation and the acquisition of elementary science. These early years, therefore, belong rightfully, and by the laws of the mental constitution, to science and the rudimentary study of natural things. It is a sufficient outrage in itself to put children at the dead languages, whereby there is certain to be engendered a hatred of study; but it is no less an outrage upon

the childish nature to neglect those studies which are best suited to this stage of his unfolding faculties.

LITERARY NOTICES.

Physical Education; or, the Health Laws of Nature. By Felix L. Oswald, M. D. New York: D. Appleton & Co. Pp. 259. Price, $1.

The health papers contributed by Dr. Oswald to the "Monthly" during the past year, having been revised by the author, are now issued in a separate form, and, as we are glad to see, at a price which will favor their wide circulation. We call attention to some points of interest in this remarkable little book.

In the first place, it must be said that the author is no mere unpractical theorizer. He is a medical man of thorough preparation and large professional experience, and an extensively traveled student of nature and of men. While in charge of a military hospital at Vera Cruz, his own health broke down from long exposure in a malarial region, and he then struck for the Mexican mountains, where he became director of another medical establishment. He there spent eight years, making many excursions to explore the imperfectly known Mexican highlands, and he has given the results of his observations and adventures in his "Summer-land Sketches," one of the most interesting and instructive books of travel that has appeared in a long time.

Dr. Oswald has also journeyed extensively in Europe, South America, and the United States, and always as an open-eyed, absorbed observer of nature and of men. So active a career we might suppose not to be in the highest degree favorable to superior literary work, which we are accustomed to expect only from the devotees of scholarship, who concentrate themselves upon books in the solitude of their libraries. And yet Dr. Oswald's merits as a writer are of a very high order. He has a genius in the use of language which is less a result of cultivation than a gift of nature. He writes in a style that is at once crisp and incisive, easy and flowing. His vocabulary is prolific, and every word is the most felicitous for its place. There is no halting and no dissonance in the musical rhythm of his periods, and there is not a weak or a faltering sentence to be found between the covers of the book on "Physical Education." He never spins out his passages, or plays with epithets for effect; and though the earnestness and ardor of expression often start the pulse, the strain of eloquence never breaks into rhetorical inflation. These traits are possessed by our author in a degree that places him, beyond question, among the few unrivaled masters of lucid idiomatic English.

In an age when the whole force of culture is thrown upon the art of effective expression, it is no easy task to reach preeminence in this field; but the interest of the case is heightened when we learn that Dr. Oswald is not an Englishman, and is not writing in his native speech, but in a foreign tongue. Macaulay, in his life of Frederick the Great, remarks, "No classic work, as far as I recollect, was ever composed by any man except in a dialect which he had learned without remembering how and when, and which he had spoken with perfect ease before he had ever analyzed its structure." The little book now before us will go far to refute this dictum of the great essayist. At any rate, we do not think the critic of the "Troy Press" is far from the truth when he declares that "Mr. Felix L. Oswald, of Cincinnati, is the cleanest writer of pure English on this continent."

But, though proficient to a rare degree in one of the most difficult arts, yet with Dr. Oswald this art is far from being an end in itself; he subordinates his gift of writing to a more serious purpose. It is by the breadth, beneficence, and vital urgency of this controlling purpose that the man is to be properly measured. With him the accomplishments of literary expression, like the facts and truths of science, only acquire their highest value as they are made tributary to human amelioration. By "physical education" he means not mere "gymnastics," as hitherto interpreted, but all hygienic and educative resources for the physical improvement and redemption of mankind. Though a man of many-sided culture, and a passionate lover of nature, and therefore with inexhaustible resources for his own mental gratification, yet Dr. Oswald is still more a

man of profound sensibility to his human environment, and of irrepressible sympathy with the weakness, the difficulties, the errors, and the miseries of his fellow-beings. His book has the double object of pointing out the more common and fruitful sources of those debilities and infirmities from which people suffer through their prejudices, ignorance, unhealthy habits, and unnatural practices, and of arousing them to more earnest, hearty, and determined effort at amendment.

It is just at this point that criticism intervenes with its accusation that our author writes with exaggeration and extravagance. If this objection implies that facts are distorted or truth overstrained in Dr. Oswald's pages, we believe it will be found to have a very slender basis; if it is a mere matter of taste, the use of superlatives is certainly excusable here if anywhere. Dr. Oswald is inspired with the hope of mending things; and, in writing for the people, he does not believe that non-committal under-statements are best suited to answer that purpose. With feeble conventional protests which arouse no indignation and provoke no action Dr. Oswald has little patience. He writes both to divert and to convert his readers, and his essays are therefore doubly contrasted with the subdued regulation monographs of a scientific period that is cultivated out of half its life. To produce any salutary and permanent reform, the evils to be corrected require to be presented in a very strong light and vividly realized. "Cool indifference, whatever subjective advantages it may have, will never set a rubbish-heap of old shams and errors afire."

There is but one thing worse, in the view of Dr. Oswald, than the injurious practices which undermine the stamina and lower the health and life of a people, and that is the dull, conventional acquiescence in a confessedly vicious state of things. Holding that this wide-spread and culpable torpor is due largely to the preaching of an ancient gospel of anti-naturalism, he maintains that its only possible counteraction is the vigorous and vehement inculcation of the gospel of nature, and his book is animated throughout with this preaching. The mere lazy indifference of those who are comfortable in prevailing customs, and content with the decorous rule of Mrs. Grundy, is sufficiently intolerable; but when these fall back upon a philosophy of life which maligns the natural instincts, libels the world we live in, and promises another to compensate for the breakdown of this, he has only hot denunciation of the doctrine and all who teach it. However we may object to pungency of speech, Dr. Oswald may at any rate plead the abundant example of his adversaries in the use of it.

The "Physical Education" is one of the most wholesome and valuable books that have emanated from the American press in many a day. Not only can everybody understand it, and, what is more, *feel* it, but everybody that gets it will be certain to read and re-read it. We have known of the positive and most salutary influence of the papers as they appeared in the "Monthly," and the extensive demand for their publication in a separate form shows how they have been appreciated. Let those who are able and wish to do good buy it wholesale and give it to those less able to obtain it. It will be a boon to benighted multitudes.

THE VOYAGE OF THE VEGA ROUND ASIA AND EUROPE, WITH A HISTORICAL REVIEW OF PREVIOUS JOURNEYS ALONG THE NORTH COAST OF THE OLD WORLD. By A. E. NORDENSKIÖLD. Translated by ALEXANDER LESLIE. With five Steel Portraits, numerous Maps, and Illustrations. New York: Macmillan & Co. Pp. 741. Price, $6.

THE frequent references which have been made within the last two years to the enterprise of which this work gives the first full and detailed account, attest the value which the world attaches to the problem which it was designed, if possible, to solve, that of forcing a northeast passage to China and Japan—a problem which, the author remarks, "for more than three hundred years had been a subject of competition between the world's foremost commercial states and most daring navigators, and which, if we view it in the light of a circumnavigation of the Old World, had, for thousands of years back, been an object of desire to navigators." Professor Nordenskiöld was led to undertake this voyage by the success of his previous voyages, in which he had reached the mouth of the Yenisei River by sea from

Sweden, in 1875 and 1876, and was convinced that the open navigable water which had carried him so far extended probably to Behring Strait. He laid his plans before the King of Sweden and other persons, who were known to sympathize with his object, and received from his Majesty, Mr. A. Sibiriakoff, and Mr. Oscar Dickson, whose portraits on steel worthily appear in the volume, pledges of substantial support, selected his company, prepared his vessels—the Vega, a steam-whaler, the Lena, as a tender to go ahead in doubtful places, and two merchant-vessels, which were to carry coal for the exploring vessels—and sailed from Maosoe, a few miles southwest of North Cape, on July 25, 1878. Here the expedition proper began and hence it was conducted through the sea that washes the northern edge of the Old World, along the coast-lines of provinces of which readers may have seen indefinite mention, and conceived hazy ideas, but of which they could have hardly had distinct notions before, till it emerged again through Behring Strait into the regions of civilization and exact knowledge. Of the sea and coasts along the Arctic borders of Europe and Asia, Professor Nordenskiöld's account gives the fullest and most interesting descriptions, touching nearly all the subjects of interest appertaining to them. First, we have the history, which in the present case naturally relates and is largely confined to previous voyages to the same regions, the relation of which, Professor Nordenskiöld remarks, adds a much-needed variety to the interest of the story, "for nearly all the narratives of the older northeast voyages contain in abundance what a sketch of our own adventures has not to offer, but what many readers, perhaps, will expect to find in a book such as this—accounts of dangers and misfortunes of a thousand sorts by land and sea." Then come geographical descriptions of features of land and sea, with the varied aspects of summer and winter phenomena according to the season when the author witnessed them; natural history, embracing the vegetable and animal life of the whole Arctic stretch covered by the voyage; geology; and the delineations of the people. In the latter category are included full and satisfactory as well as entertaining accounts of those curious tribes, the Samoyeds and the Chuckchees, their mode of life, habits and manners, and religion, which are rich in incidental and personal sketches, are given in the kindliest of feeling and with delicate humor, and form, perhaps, to general readers, the most interesting part of the book, while they must also rank high as anthropological studies. A prominent object of the voyage was to study the feasibility of opening a commercial highway from Europe to the river-marts of Central and Eastern Siberia, by way of the sea-route which the expedition took. Professor Nordenskiöld's estimate of the productive capacity of these regions of the far North, and of their possible value in the world's economy if they could be brought within reach of the markets, may be a surprise to those who have associated with Siberia all that is frozen and inhospitable. "If we take Siberia in its widest sense," he says, "that is to say, if we include under that name not only Siberia proper, but also the parts of High Asia which lie round the sources of the great Siberian rivers, this land may very well be compared in extent, climate, fertility, and the possibility of supporting a dense population, with America north of 40° north latitude. Like America, Siberia is occupied in the north by woodless plains. South of this region, where only the hunter, the fisher, and reindeer nomad can find a scanty livelihood, there lies a widely extended forest territory, difficult of cultivation, and in its natural conditions, perhaps, somewhat resembling Sweden and Finland north of 60° or 61° north latitude. South of this wooded belt, again, we have, both in Siberia and America, immeasurable stretches of an exceedingly fertile soil, of whose power to repay the toil of the cultivator, the grain exports during recent years from the frontier lands between the United States and Canada have afforded so striking evidence. There is, however, this dissimilarity between Siberia and America, that, while the products of the soil in America may be carried easily and cheaply to the harbors of the Atlantic and Pacific, the best part of Siberia, that which lies around the upper part of the courses of the Irtish, Obi, and Yenisei, is shut out from the great oceans of the world by immense tracts lying in front of it, and the great rivers which in Siberia cross the

country and appear to be intended by nature to form not only the arteries for its inner life, but also channels of communication with the rest of the world, all flow toward the north, and fall into a sea which, down to recent times, has been considered completely inaccessible." The basins of the three great rivers together cover an area of nearly 2,500,000 geographical square miles, of which 1,440,000 geographical square miles lie south of 60° north. A part of the journey lay through the region of the remains of the mammoth, and "between shores probably richer in such remains than any other on the surface of the globe, and over a sea, from whose bottom our dredge brought up, along with pieces of drift-wood, half-decayed portions of mammoth-tusks." The business of gathering and disposing of these tusks is really an important one, estimated to amount to a hundred pairs a year, or twenty thousand pairs since the country was conquered. These figures indicate that the mammoth population of the country must have been more considerable than the impression of the barrenness of the Arctic regions which is given by a superficial view leads us to suppose could have been the case. Professor Nordenskiöld finds no difficulty, however, in indicating the sources whence these animals derived their food. Having remarked that the remains of food which were found in the hollows of the teeth of a rhinoceros discovered on the Wilui River consisted of portions of leaves and needles of species of trees that still grow in Siberia, he observes that "it ought not to be overlooked that in sheltered places overflowed by the spring inundations there are found, still far north of the limit of trees, luxuriant bushy thickets, whose newly expanded juicy leaves, burned up by no tropical sun, perhaps form a special luxury for grass-eating animals, and that even the bleakest stretches of land in the high north are fertile in comparison with many regions where at least the camel can find nourishment."

Even now the animal life in the extreme north, as in Nova Zembla, in summer, "is more vigorous and, perhaps, even more abundant, or, to speak more correctly, less concealed by the luxuriance of vegetation, than in the south." Especially is this the case with "the innumerable flocks of birds that swarm around the polar traveler during the long summer days of the north." Insects, also, of a few species, are remarkably abundant, considering that the soil is continually frozen below the depth of a few inches, but as a rule "the actual land vertebrate fauna of the polar countries is exceedingly scanty in comparison with that of more southerly regions. It is quite othwise as regards the sea. Here animal life is exceedingly abundant as far as man has succeeded in making his way to the farthest north. At nearly every sweep the dredge brings up from the sea-bottom masses of decapods, crustacea, mussels, asteroids, echini, etc., in varying forms, and the surface of the sea on a sunny day swarms with pteropods, beroids, surface-crustacea, etc. "A greater number also of the higher types of animals within the polar territory occur in the sea than on the land. Having spent a winter in the frozen ocean, the expedition proceeded easward to and through Behring Strait, and calling, always with scientific intent, at Japan, China, and the East India islands, came around through the Red Sea, the Suez Canal, the Mediterranean, and the Atlantic Ocean, to its starting-point in the Scandinavian waters, thus accomplishing, for the first time in history, the circumnavigation of Europe and Asia.

Lectures on the Origin and Growth of Religion as illustrated by Some Points in the History of Indian Buddhism. By T. W. Rhys Davids. New York: G. P. Putnam's Sons. Pp. 262. Price, $2.50.

A religion which is believed to embrace more adherents than any other system of religious thought; the fundamental principles of which are embodied in a literature the merit and intrinsic interest of which have received the general recognition of scholars in all nations; and some of the external aspects of which present a striking resemblance to some Christian forms, is entitled to be regarded as a most remarkable outgrowth and manifestation of human thought, and deserves profound and respectful study. Buddhism is such a religion as we have described, and it receives the treatment it merits at the hands of Mr. Davids, who is considered one of the most competent living authorities on the subject. It has to be

examined by nations, for it presents very varied phases in different countries, according as it has been modified by the character and circumstances of their people and by their history. Everywhere, however, India is looked to as the land of its origin; and it is in India that its oldest and most important books are found. Mr. Davids has, therefore, very properly selected India as the country in which to consider it for the elucidation of its fundamental principles. His lectures, which were delivered on the Hibbert foundation, consider, first, "The Place of Buddhism in the Development of Religious Thought," under which head the author reviews the condition of India at the time of the introduction of Buddhism, the effect the new religion had on that condition, and the influence the condition exerted upon the shape it eventually took; and, afterward, the "Pali Pitakas," or the principal books of Buddhism—the Buddhist theory of Karma, or what takes the place, with a striking difference, of the Christian idea of the future life; the "Buddhist Lives of the Buddha"; "Gotama's Order," or the rules that were laid down by the founder of the religion himself; and "The Later Forms of Buddhism," which are immense in their variety. Among the lessons to be derived from the study, Mr. Davids points out that "the knowledge of what man has been in distant times, in far-off lands, under the influence of ideas which at first sight seem to us so strange, will strengthen within us that reverence, sympathy, and love, which must follow on a realization of the mysterious complexity of being, past, present, and to come, that is wrapped up in every human life."

Bacteria. By Dr. Ferdinand Cohn. Translated by Charles S. Dolley, Rochester, New York. Pp. 30, with a Plate.

The title of this paper and the name of its author commend it without any further words. We need notice especially only the translator's statement of one of his objects in offering it, which is, to set the example of publishing scientific books in cheap editions, as is done abroad. The plate of illustrations consists of figures that were drawn by Dr. Cohn himself for "The Microscopical Journal."

Beliefs about Man. By M. J. Savage. Boston: George H. Ellis. Pp. 130. Price, $1.50.

This work, a complement to a previously published volume on "Belief in God," embraces the substance of a number of regular Sunday-morning sermons on the nature, origin, and destiny of man, in which were also considered some of the problems, such as those of sin and salvation and of free-will, which have troubled him during all the ages. The points brought out may be summed up in brief, that "man is the animal that has learned to think of himself, to think of right, to think of God, and has ended by thinking that he is a son of God"; that the doctrine of evolution has no relation to theism or atheism; that the doctrine of necessity, as distinguished from free-will, "gives us motive power, gives us a way to work, gives us confidence that our work will not be without its appropriate results"; that the forces, the powers, that are at work in human nature to-day do not need uprootal or change, but only instruction, guidance, self-control; that the perfect city of God is to begin here; that the absolute conditions of progress are freedom and knowledge; and that death is not the end, but may be simply the fitting for "that other, higher life, that we may trust surrounds us everywhere now, and of which, even to-day, unknowingly, we are a part."

Transactions of the Medical Association of Georgia. Thirty-second Annual Session, 1881. Edited by Dr. A. Sibley Campbell, M. D., Secretary. Augusta, Georgia: Pp. 314. Price, $1; by mail, $1.05.

This volume includes the papers which were read at the meeting of the association whose proceedings it records; which papers pertain to appropriate subjects in medical and surgical treatment, and are based upon material drawn chiefly from cases in the practice of their authors. The one, perhaps, of most general interest is that of Dr. R. J. Nunn, on "Female Diseases, the Result of Errors in Habit and Hygiene during Childhood and Puberty." Illustrations are given where the matter calls for them. The necrology of members of the association who died during the year is followed by a number of biographies of physicians previously

deceased, among which a conspicuous position is given to that of Dr. Crawford W. Long, for whom is claimed absolute priority in the discovery of anæsthesia by ether, and who died in 1878, "at the bedside of a patient, in the discharge of his duty."

The Universe; or, The Infinitely Great and the Infinitely Little. By F. A. Pouchet, M. D. Sixth edition. Illustrated by 270 Engravings on Wood. New York: G. P. Putnam's Sons. Pp. 564. Price, $3.75.

To present the leading facts of nature to the non-scientific public in such a style that it will read of them with the interest with which it follows the development of a romance, without detracting from the dignity and accuracy of scientific statement, to compose such a vivid word-picture as shall enable the reader to form an adequate conception of the marvelousness of the wonders that science has discovered, without falling into exaggeration and sensationalism, are tasks which the most learned investigator in science and the best-trained writer would be justified in shrinking from attempting. Only a man of strong imagination, combined with an unusually even mental poise, could undertake to carry a series of description of this character through the whole field of nature. M. Pouchet has undertaken this, and has accomplished it successfully. He leads us in his most entertaining work, which the child or the student of science may read with equal pleasure, by successive steps, truly from the infinitely little to the infinitely great. Beginning with the invisible world of the microscope, which includes the animalcules that still live in our fluids, the fossil infusoria of the edible earths, and the nummularia of the limestones of which cities and the pyramids are built, and the "architects of the sea," the corals, the boring mollusks, and the "mountain-building" foraminifera, he goes on to make us acquainted with the insects, the abundance of their life, and the magnitude of their works and their depredations, the birds and the artful structures of which they are the architects, and with the wonderful migrations of animals of every class. Then, passing to the vegetable kingdom, he illustrates the anatomy and physiology of plants, the functions of the seed and the process of germination, the "extremes in the vegetable kingdom," from the lichen of the rock to the baobabs and sequoias of the primeval forest, and discourses of the longevity and density of plants, and their migrations, even more wonderful than those of animals. Next the department of geology is brought under review, with an account of the formation of the globe by gradual development and change as recorded on the tablets of the rocks, descriptions of fossils, embracing here again the extremes, though not infinite, of the little and the great—"the mountains, cataclysms, and upheavals of the globe, volcanoes and earthquakes, glaciers and eternal snows, caverns and grottoes, steppes and deserts, and the air and its corpuscules. The "Infinitely Great" is represented in the sidereal universe, under which head are considered "The Stars and Immensity" and the solar world. The final chapter gives a brief account of the monsters and superstitions, belief in which was cultivated in the middle ages. The author declares—and his work bears him out—that his object in composing it has been to inspire and extend to the utmost of his power a taste for natural science: hence, he has given, "not a learned treatise, but a simple elementary study, conceived with the idea of inducing the reader to seek in other works for more extensive and more profound knowledge." We can only refer to the richness of details that characterizes the work and the excellence of the illustrations.

The Gospel in the Stars; or, Primeval Astronomy. By Joseph A. Seiss, D. D. Philadelphia: E. Claxton & Co. New York: E. P. Dutton & Co. Pp. 452. Price, $1.50.

The author of this work, a prominent Lutheran clergyman, has already acquired considerable distinction from the zeal with which he has propagated Piazzi Smyth's theory that the great pyramid of Egypt was constructed in pursuance of a divine revelation, for a divine purpose. He here propounds a similar theory for the formation and delineation of the forty-eight original constellations of the sky, which he believes were primarily composed under inspiration, to typify man's redemption by Christ. Whatever skeptics, readers, and scholars may think of the matter, he has no doubt about it.

The Art of Voice-Production, with Special Reference to the Method of Correct Breathing. By A. A. Patton, author of "The Voice as an Instrument." New York: G. P. Putnam's Sons. Pp. 106. Price, $1.

Application is made in this work of the investigations which have been carried on, by means of the laryngoscope, into the structure and mode of action of the vocal organs, to the study of a scientific cultivation, or, as the author, with but little exaggeration, calls it, production of voice. The foundation of voice-culture is laid in correct breathing. This should always be full and easy, and done by the action of the muscles of the diaphragm, not of the clavicle or ribs. The technic consists in learning to know when the voice-organs act properly, and how to make them act so. Particular stress is laid upon what is called the articulate action of the glottis—an action under which, in its perfection, the individual notes of a series are divided in such a manner that a complete scale of fractional tones of very small degree may be produced with perfect smoothness, and with unchanging though naturally modifying tone-quality, by the voice, as the best violinists accomplish the same through their instruments. To this, the author believes, such singers as Nilsson and Santley owe their marvelous powers of execution; and, in illustration of the fineness to which it is possible to reduce it, the case is cited of Madame Mara, who was able to perform twenty-one hundred changes of pitch within the compass of three octaves, or one hundred changes between each two notes of the ordinary scale.

The Study of Trance, Muscle-Reading, and Allied Nervous Phenomena, in Europe and America. With a Letter on the Moral Character of Trance-Subjects; and a Defense of Dr. Charcot. By George M. Beard, A. M., M. D. New York. Pp. 40.

This is a setting forth, in brief, of what has been done in Europe during the past two or three years, in a department of psychology in which the author was one of the earliest and is still one of the most indefatigable workers, and offers a means of comparing American (of which Dr. Beard's have been the most conspicuous) and European researches in it.

Sparks from a Geologist's Hammer. By Alexander Winchell, LL. D. Chicago: S. C. Griggs & Co. Pp. 400. Price, $2.

This is a very pleasant volume of essays, descriptive, scientific, and philosophic, though predominantly geological, and written in a style intended to suit the general reader. As is well known, the author has command of a very entertaining style, and his long and varied experience with the practical study of nature has given him ample materials for an attractive volume. Books of this kind perform a most important office, not only in awakening a feeling for science, but in instructing the public on many interesting topics which are hardly touched in our scientific manuals. A few of his titles will suggest the variety there is in these pages: "Mont Blanc and its Ascent," "Obliterated Continents," "A Grasp of Geological Time," "Geological Seasons," "Salt Enterprise in Michigan," "Huxley and Evolution," and "The Metaphysics of Science." We need not commit ourselves to everything Professor Winchell says in this volume, but it will prove instructive and provocative of thought to most readers, and may be therefore cordially recommended.

Principles of Chemical Philosophy. By Josiah Parsons Cooke, of Harvard College. Revised edition. Boston: John Allyn. Pp. 623. Price, $3.50.

We are glad to see that this well-known standard work devoted to the higher grade of chemistry has undergone careful and extensive revision by the author, and been so largely rewritten as to make it in many respects a new book. Not only is the work itself essentially improved by this further elaboration, but the results of the last ten years of chemical progress are thoroughly embodied in its text, and many features of scientific interest are here brought forward for the first time. The distinctive aim of the work is philosophical, that is, it presents the great body of the chemical truths in a closely correlated and thoroughly systematized form. "Thus alone," says the author, "can the student give breadth and dignity to his knowledge, and come to know nature not as a sum of certain parts, but as a grand and related whole." Such a generalized knowledge of chemistry this book aims to

impart. It presents chemistry as a philosophic system, and it deals with the facts of the science only so far as they illustrate this system. It is not intended in any respect to take the place of laboratory teaching, but solely to supplement it. Not until the student has become familiar with chemical phenomena, at least to some limited extent, is he prepared to study the science in a systematic way; but all who have this preparation will acquire most rapidly a general knowledge of the whole field when the subject is presented in a deductive form.

Report of the Director of the Astronomical Observatory of Harvard College. By Edward C. Pickering. Cambridge: University Press. Pp. 16.

This is the thirty-sixth annual report of the institution. Mention is made of the improved position that has been given the Observatory for conducting researches by means of the subscription which was raised in 1878. Observations have been made on eclipses of Jupiter's satellites, the spectra of particular stars, the comets of 1881, variable stars, and the working of the instruments, and also photometric observations. Some interesting results have been derived from the observations on stellar spectra, one of them giving a hint toward a more rapid method of detecting variable stars, another suggesting analogies between the spectrum of a certain star and that of the great comet of 1881. Mr. Chandler, of the observatory staff, is engaged in collating, for comparison, the observations of stars of known or suspected variability.

The Palæolithic Implements of the Valley of the Delaware. Cambridge, Massachusetts: Peabody Museum of American Archæology and Ethnology. Pp. 25.

This publication contains communications which were made on the subject named in the title to the Boston Society of Natural History at one of its meetings, as follows: "Historical Sketch of the Discovery of the Implements," by C. C. Abbott; "A Comparison of them with Palæolithic Implements from Europe," by H. W. Haynes; "On the Age of the Trenton Gravel," by G. F. Wright; "Statement relating to the Finding of an Implement in the Gravel," by Lucien Carr; and "On the Lithological Character of the Implements," by M. E. Wadsworth. Mr. F. W. Putnam furnishes the concluding remarks, in which he describes the finding of three implements by himself and a companion, and adds, "Certainly the evidence that has been brought forward to-night will clear away all doubts as to the importance and reliability of Dr. Abbott's discoveries and investigations, which have proved the former existence of palæolithic man in the valley of the Delaware."

Chemical and Physical Analysis of Milk, Condensed Milk, and Infants' Milk-Foods, with Special Regard to Hygiene and Sanitary Milk-Inspection. By Dr. Nicholas Gerber. Translated and edited by Dr. Hermann Endemann. Illustrated. New York. Pp. 101.

The author of this treatise has been engaged, scientifically and practically, in the dairy industry for several years, and is now manager of a milk-product company in the interior of the State of New York. Having often himself felt the need of a uniform method of analysis for milk and its products which would satisfy practical wants, and possess scientific accuracy, he has aimed to give in this volume a short and exact method for the examination of the various milks and milk-foods, expecting to follow it up with another volume on other milk-products and substances employed in the dairy industry. He claims superiority for his method over the methods known before 1877, in accuracy, in simplicity, and in cheapness and economy of time.

The Brain of the Cat. By Burt G. Wilder, M. D. Pp. 39, with Four Plates.

This paper, which was originally read before the American Philosophical Society, is the first of a series of contributions to the knowledge of the brain of the domestic cat, and is to be followed with a "Description of the Cerebral Fissures, together with their Synonomy." The author believes that the cat offers superior advantages over other easily accessible animals for preliminary anatomical work. He also proposes a revision of anatomical nomenclature, with a schedule of alterations for abbreviating and simplifying it, and making it more intelligible.

Publications of the Massachusetts Institute of Technology, and of its Officers, Students, and Alumni. 1862–1881. Compiled by William Ripley Nichols, S. B. Boston: A. A. Kingman. Pp. 50.

The list is intended to include the books, pamphlets, reports, and contributions to periodicals (excepting daily journals) printed during the time included within its scope, by the Institute officials and its affiliated societies and associations; by professors and other instructors during their connection with the school; by special students during their connection with the school; and by alumni and holders of certificates of proficiency during their connection with the school and in after-life. The list is of considerable size, covers a variety of subjects, literary and scientific, includes many titles from foreign journals, and is creditable to the institution and to American research.

The Science of Mind. By John Bascom, author of "The Principles of Psychology," "Comparative Psychology," etc. G. P. Putnam's Sons. Pp. 462. Price, $2.

The first thing to be said about Dr. Bascom's various philosophical works is that the handling of the subjects is his own, and in stamping upon them the individuality of his own mind he gives them a new and attractive interest. And that freedom and freshness which he maintains in his methods of statement are to no small degree preserved in the elucidation of his views. He is in no sense either a compiler or a servile expositor of established opinions, but he is an independent (we had almost said a *free*) thinker upon his chosen themes of study. Although by no means always up to the times, he is always in a progressive way, and moves as fast, perhaps, as the circumstances will allow. His present work, "The Science of Mind," though avowedly and essentially metaphysical, and standing squarely upon intuitional or transcendental ground, is still a very different book from its predecessors of the same class, and shows that the intelligent metaphysician is compelled to yield to the advance of scientific knowledge.

Dr. Bascom does not sympathize with the current reproaches of metaphysical philosophy, but recognizes that, like all other imperfect and difficult things, it may be and must be practically improved. In his preface he says: "If asked why I hoped that this volume might reward study, I should answer, not because the system presented is new, but because the statement it here receives is at once succinct and elaborate, is strengthened by new points, by a consistent maintenance of all that belongs to it, and by the rejection of that which, essentially alien to its principles, only embarrasses it. I trust the intuitive philosophy will be found hereby to have gained somewhat of that proof which springs from completeness and proportion of parts."

PUBLICATIONS RECEIVED.

Political Economy in One Lesson. By Alphonse Courtois. New York: The Society for Political Education. 1882. Pp. 20.

Formula and Tables for the Horse-Power of Leather Belts. By A. F. Nagle, M. E. Providence, Rhode Island: J. A. & R. A. Reid, printers. 1882. Pp. 8.

A Free Canal. Letter of ex-Governor Seymour. Pp. 5.

Some Points relating to the Geological Exploration of the Fortieth Parallel. By M. E. Wadsworth, Ph. D. Reprint from "Proceedings of the Boston Society of Natural History." Pp. 32.

History of the Water-Supply of the World. By Thomas J. Bell. Cincinnati, Ohio: Peter G. Thomson. 1882. Pp. 134.

The Geological and Natural History Survey of Minnesota. Ninth Annual Report. By N. H. Winchell, State Geologist. St. Peter: J. K. More, State Printer. 1881. Pp. 392.

The Constants of Nature. Part V. A Recalculation of the Atomic Weights. By Professor F. W. Clarke, S. B. Washington: Smithsonian Institution. 1882. Pp. 271.

Natural Law, or the Science of Justice. Part I. By Lysander Spooner. Boston: A. Williams & Co. 1882. Pp. 16.

Our Homes. By Henry Hartshorne. Philadelphia: P. Blakiston, Son & Co. 1882. Pp. 149. 50 cents.

Report to the State Board of Health on the Methods of Sewerage for Cities and Large Villages in the State of New York. By James F. Gardiner, Director of the New York State Survey. Pp. 15.

Nervous Shock as a Therapeutical Agent. By Romaine J. Curtis, M. D. "St. Louis Medical Journal" Publishing Co. 1882. Pp. 13.

The Germination and Vitality of Seeds. By Richard E. Kunze, M. D. Pp. 14. 50 cents.

National Regulation of Interstate Commerce. By C. C. Bonney. Chicago: Legal News Co. 1882. Pp. 32.

A Free Canal. Argument of the New York Produce Exchange in favor of making the Canals of the State free from Tolls. 1882. Pp. 18.

The Books of Chilan Balam: The Prophetic and Historic Records of the Mayas of Yucatan. By Daniel G. Brinton, M. D. Philadelphia: Edward Stern & Co. 1882. Pp. 19.

Anæsthesia and Non-Anæsthesia in the Extraction of Cataract. By Haskett Derby, M. D. Cambridge: Riverside Press. 1882. Pp. 32.

Studies from the Biological Laboratory of Johns Hopkins University. Professor H. Newel Martin, Editor; Professor W. K. Brooks, Associate Editor. Baltimore: N. Murray. Vol. II, No. 2. 1882. Pp. 178. Illustrated.

Cotton-Seed: The Greatest Wonder of the Present Day. By Professor J. P. Stelle. Mobile. 1882. Pp. 8.

Hints and Suggestions for Reform in Medical Education. By Frederic R. Sturgis, M. D. New York: William Wieser, printer. 1882. Pp. 13.

Bulletin of the Buffalo Society of Natural Sciences. Vol. iv, No. II. Buffalo: Bigelow Brothers, Printers. 1882. Pp. 63. Illustrated.

Experiments in Amber Cane and the Ensilage of Fodders at the Experimental Farm, Madison, Wisconsin. David Atwood, printer. 1882. Pp. 78.

The Mistakes of Robert G. Ingersoll on Nature and God. A Scientific Criticism. By George W. Edgett. Boston: Thomas Todd, printer. 1881. Pp. 37.

Insects injurious to Forest and Shade Trees. By A. S. Packard, Jr., M. D. Washington: Government Printing-Office. 1881. Pp. 275. Illustrated.

Report on a Water Supply for New York and other Cities of the Hudson Valley. By J. T. Fanning, C. E. New York. 1881. Pp. 38. Illustrated.

On Ovariotomy. By Thomas Keith, M. D. Louisville, Kentucky: John P. Morton & Co., printers. 1881. Pp. 19.

Epidemic Convulsions. By David W. Yandell, M. D. Louisville, Kentucky: printed by John P. Morton & Co. 1881. Pp. 15.

A Discourse on the Life and Character of Dr. Richard O. Cowling. By David W. Yandell, M. D. Louisville, Kentucky: printed by John P. Morton & Co. 1882.

Statistics of the Production of the Precious Metals in the United States. By Clarence King. Washington: Government Printing-Office. 1881. Pp. 94. With Plates.

Gloria. A Novel. By R. Perez Goldos. From the Spanish, by Clara Bell. In two volumes. New York: William S. Gottsberger. 1882.

Polly's Scheme. By Corydon. Boston: D. Lothrop & Co. 1882. Pp. 207. $1.

The Chemistry of Cooking and Cleaning. By Helen H. Richards. Boston: Estes & Lauriat. 1882. Pp. 90.

Vaccination. Arguments Pro and Con. By Joseph F. Edwards, M. D. Philadelphia: P. Blakiston, Son & Co. 1882. Pp. 80. 50 cents.

First Aid to the Injured. By Peter Shepherd, M. B. Revised by Bowditch Morton, M. D. New York: G. P. Putnam's Sons. 1882. Pp. 87. 50 cents.

How to Make the Best of Life. By J. Mortimer Granville, M. D. Boston: S. E. Cassino. 1882. Pp. 96. 50 cents.

Easy Lessons in Light, by Mrs. W. Awdry, 114 pages; and Easy Lessons in Heat, by P. A. Martineau, 136 pages. London: Macmillan & Co. 1880.

The Rhymester, or the Rules of Rhyme. By the late Tom Hood. Edited, with Additions, by Arthur Penn. New York: D. Appleton & Co. 1882. $1.

The Occult World. By A. P. Sinnett. Boston: Colby & Rich. 1882. Pp. 172. $1.

Tables for the Determination, Description, and Classification of Minerals. By James C. Faye, Ph. D. Chicago: Jansen, McClurg & Co. 1882. Pp. 85. $1.

John Stuart Mill: A Criticism. With Personal Recollections. By Alexander Bain, LL. D. New York: Henry Holt & Co. 1882. Pp. 200. $1.25.

James Mill: A Biography. By Alexander Bain, LL. D. New York: Henry Holt & Co. 1882. Pp. 466. $2.

The Wine Question in the Light of the New Dispensation. By John Ellis, M.D. New York: published by the author. 1882. Pp. 228.

The Practice of Commercial Organic Analysis. By Alfred H. Allen, F. C. S. Vol. ii. Philadelphia: Presley Blakiston. 1882. Pp. 561. $5.

Annual Report of the State Geologist of New Jersey for the Year 1881. By Professor George H. Cook. Trenton, New Jersey: J. L. Murphy, printer. 1881. Pp. 107.

POPULAR MISCELLANY.

Purification of the Boston Water-Supply.—The water with which the city of Boston is supplied became affected last October by a peculiar and disagreeable taste and odor which made it unpalatable, and justified much complaint on the part of citizens. The taste was quite accurately described as a "cucumber-taste," from its resemblance to the taste of water which has stood in contact with cucumbers. In a milder form it was called a "fish-oil taste." After several efforts to determine its origin, Professor Ira Remsen, of Baltimore, was called in to give the subject a thorough examination. He, after patient investigation and experiments, which failed to discover the cause of the odor in other matters, determined its source, by the most satisfactory tests, to be the decomposition of a fresh-water sponge (*Spongilla fluviatilis*), that was found quite abundantly in the mud of the bottom of Farm Pond, the water of which was most offensive. Measures have been taken to free the pond from the cause of impurity.

The Hessian Fly.—From a monograph published by Professor A. S. Packard, Jr., through the United States Entomological Commission, it appears that the losses from the Hessian fly are greatest in the grain-raising areas of the Middle and Northwestern States and the adjoining regions of Canada, while the New England States have been comparatively free from its attacks, probably because so little wheat is cultivated in them. No statistics as to the losses have ever been collected, but they have been sufficient to occasion much consternation and alarm in certain years. Two

broods of the fly are produced in a year, the first laying its eggs in April and May, the second in August and September. The damage is done by the larva, which lies at the sheathing base of the leaves first above the roots, at or near the surface of the soil, and absorbs the sap from the stalks. From the larva, the insect passes into the pupa state, in which it resembles a flaxseed, and remains in it for the five winter months. The pest flourishes best in rather warm and moist seasons; and it has been noticed that the years when it has been most abundant have been characterized by weather answering to that description. It is afflicted by several parasites by which it is said that nine tenths of every generation of the insects are destroyed. The principal parasites are a chalcid fly that destroys the pupa, and a platygaster, which lays its eggs in the egg. Professor Packard recommends, as remedies for the insect, late sowing of fall wheat, so that the flies may be killed by frost before laying their eggs, high culture to give the plant new vigor, the sowing of the most vigorous and many-stooled varieties, and pasturing, which destroys the "flaxseeds," but is "a rather rude, uncertain remedy." Special remedies like limeing, dusting, burning stubble, etc., are not recommended, because they are inferior to those just mentioned, and are as likely to destroy the helpful parasites as the harmful flies. A comparison of the periods when the flies have been most abundant indicates that the plague has culminating periods in the neighborhood of twenty-five years apart.

Folk-Lore of the Mammoth.—Baron Nordenskiöld, in his "Voyage of the Vega," gives some interesting citations of the folklore of the Siberian natives respecting the mammoth, whose remains are very abundant in the country. Evert Yssbrants Ides, a Russian embassador in 1692, related that the heathen Yakuts, Tunguses, and Ostiaks, supposed that the mammoth always lived in the earth and went about in it, however hard the ground might be frozen, and that it died when it came so far up that it saw or smelled the air. J. B. Müller, in 1720, added that the tusks were believed to have formed the animal's horns, that they were fastened above the eyes and were movable, and that with them the animal dug a way for itself through the mud; when it came to a sandy soil, the sand ran together so that the mammoth stuck fast and perished. Müller further stated that many natives assured him that they themselves had seen such animals in large grottoes in the Ural Mountains. Klaproth says that the Chinese at Kiakhta considered mammoth ivory the tusks of the giant rat, *tien-shu*, which is found only in the cold regions along the coast of the Polar Sea, avoids the light, and lives in dark holes in the interior of the earth. Some of the *literati* believed that the discovery of these immense earth-rats might even explain the origin of earthquakes. The horns and crania of the rhinoceros, which were found along with the remains of the mammoth, were believed to have belonged to gigantic birds, concerning which stories were related analogous to those told of the roc in the "Arabian Nights." Pieces of the horns were used to increase the elasticity of bows, and were believed to exert a beneficial effect on the arrow, and to tend to make it hit the mark. Ermann and Middledorf suppose that the finds of these remains two thousand years ago gave occasion to Herodotus's account of the Arimaspi and the gold-guarding dragons. Certain it is that during the middle ages such "grip-claws" were preserved as of great value in the treasuries and art collections of the time, and that they gave rise to many a romantic story in the folk-lore, both of the West and the East. Even in our own century, Hedenström, in 1830, otherwise an intelligent traveler, believed that the fossil rhinoceros-horns were actual "grip-claws."

Water-Temperatures at the Top and Bottom of Lakes.—Professor William Ripley Nichols has obtained, from the examination of the relative temperatures of the surface and the depths of fresh-water ponds near Boston, Massachusetts, results that differ from the views on this subject that are commonly held and taught. In Fresh Pond and Mystic Pond considerable difference was shown to exist in the temperature at the top and at the bottom, and the temperature appeared to decrease regularly from top to bottom. Having compared his own observations with those made in Swiss and

Scotch lakes, in winter as well as in summer, Professor Nichols is led to the conclusion that "the water of lakes and ponds is, as a rule, before freezing, cooled to a temperature much lower than 4° Cent. (39° Fahr.), not simply at the surface, as generally stated, but to a considerable depth. The commonly received idea and the current statements of the text-books of chemistry and physics, are, therefore, misleading." The temperature of the water at the bottom of deep lakes is, moreover, not constant at the point of greatest density, as is frequently stated, but often lies appreciably above that point. Professor Nichols is not satisfied that we know sufficiently well the depth to which the diurnal variations of temperature extend under different circumstances. The curves of temperature in Mystic Pond show that there were several times when a few successive days of warm or cold weather produced an effect on the water, even at a depth of seventy-five feet. The paper recording these observations is supplemented by a list of other publications and papers bearing on the subject.

Sanitary Reports of British Schools.—The "Lancet" about a year ago addressed a series of questions to the managers of English schools respecting their sanitary provisions and the health of their pupils. The answers which it has received indicate that the subject is given considerably more attention than it was a few years ago, and that many of the managers sympathize with the editor in the object of his inquiries—that of ascertaining the conditions of the best scholar-health. The first report made by the journal summarizes the replies received from thirty-nine schools, in relation to the points of the character of the situation and buildings, and the climatic conditions; the amount of air-space per pupil in the sleeping- and school-rooms; general state of health, cases of illness; sanitary arrangements as regards drainage, closets, lavatories, bathing, towels, etc.; provisions for the isolation of contagious cases; and provisions for medical inspection. No particular relation seems to be shown between the presumed healthful or unhealthful character of the site, and the presence or absence of disease. The sleeping-rooms afford from 273 to 1,300 cubic feet of air per individual; if the schools were full, the probable average allotment would be between 300 and 400 feet. The provision of air in the school-rooms is "fairly ample." The drainage is pronounced good in nearly every school, and no cases of illness are mentioned which could be traced to defective drainage. Lavatory arrangements are well attended to, with provisions for hot, cold, and swimming baths, and separate towels, brushes, etc., for each boy. Eight schools report that no cases of illness occurred during the year, one never having occasion to send for the doctor. The diseases mentioned include ophthalmia in two schools, pneumonia in two, "congestion of the lungs" in two, peritonitis in one, rheumatic fever and erythema nodosum in one, and sore-throat in one. Measles occurred in fifteen schools (fifteen cases in one), scarlet fever in twelve (fourteen cases with one death in one school), varicella in two, mumps in three (thirty cases in one school), Rötheln in three, whooping-cough in two, and typhoid fever in one. Many of the schools have provision of some kind for the isolation of pupils sick with contagious disease. Only five schools have arrangements for systematic medical inspection. The value of these returns is modified by the fact that the schools having the best sanitary arrangements and showing the best condition would naturally be the ones most ready to report.

Recent Existence of the Mastodon.—Professor Collett's "Geological Report of Indiana for 1880" mentions some new facts that seem to indicate that the mastodon existed in our country at a more recent date than is commonly supposed. In nearly all the specimens that have been found, generally in places where the animal has been mired, the skeletons are in a greater or less state of decay. In a skeleton discovered a few years ago, in Fountain County, the marrow of the larger bones was used by the workmen to grease their boots, and the place of the kidney-fat was occupied by lumps of adipocere. During the summer of 1880 a mastodon was found in Iroquois County, Illinois, that gave every evidence of having lived among the same life and

vegetation as prevail to day. A mass of fibrous, bark-like material was found between the ribs, filling the place of the animal's stomach, which proved to be composed of crushed herbs and grasses, similar to those that still grow in the vicinity. In the same beds of miry clay, a multitude of small fresh-water and land shells were observed and collected, of mollusks which prevail all over the States of Illinois, Indiana, and parts of Michigan. These facts afford strong evidence that animal and vegetable life, and consequently climate, are the same now as when the mastodon lived.

Some Rare Meats.—The flesh of the elephant is relished by the inhabitants of many districts of Africa and Asia. Major Denham says that it is esteemed by all, and that, though it looks coarse, it is better flavored than the beef of the country. Gordon Cumming speaks of the dainty dishes of baked elephant's feet and elephant's trunk, which, prepared after a way he describes at length, very much resemble buffalo's tongue. Le Vaillant says that baked elephant's foot is a dish fit for a king; but Captain Lindley likens it to "very soft leather and glue mixed together." Hippopotamus-meat is appreciated in Africa by both natives and European colonists, but Dr. Schweinfurth and Captain Lindley do not find it so appetizing. The fat of this animal and of the rhinoceros is considered delicious, and is used instead of butter. The Portuguese settlers are permitted to eat the flesh of these animals during Lent, passing it off as fish. The flesh of the American tapir, somewhat resembling unsavory, coarse, and dry beef, is considered palatable by the Indians, and the fatty protuberance on the nape of its neck, and the feet and groin, cooked to a jelly, are regarded as great delicacies. The horse is said to have been universally used as food before the period of civilization, and was greatly liked by the ancient Germans and Scandinavians. Mungo Park speaks of wild horses being eaten in Africa. Mare's flesh is a choice morsel to the Chilian Indians. The efforts to reintroduce horse-flesh as food have had considerable success in some European capitals. The Greeks ate donkeys; the flesh of the wild ass is held in high esteem by the Persians and Tartars; and the quagga and zebra form favorite dishes among the Hottentots and in Central Africa. Camel's flesh is highly esteemed in Africa, but is not liked by the Tartars. The hump, however, cut in slices and soaked in tea, serves the purpose of butter. The South American alpaca affords a flesh little inferior to mutton. The flesh of the young giraffe is very delicate, and the marrow is held at a high value. Passing the animals of the deer and bovine tribes, which are appreciated by all, we come to the whales and seals, which furnish a chief part of the food-supply of the Esquimaux. The walrus is also highly esteemed in the Arctic regions, and its tongue, heart, and liver are often eaten by whalers in the lack of better provisions. The dolphin is eaten at the Faroe Islands, where two thousand individuals are taken annually. The flesh of the dugong is good and palatable, having the flavor of pork combined with the taste of veal, and is esteemed a great delicacy by the Mohammedan Malays, who find in it a substitute for the pork that is forbidden them. The meat of the young animal salted and cured, with the flesh and fat in its alternate layers, produces a bacon which can not be distinguished from that of real pig, and which finds a ready sale in Queensland. The oil, properly tried out, is equal to fresh butter.

Suggestions to Observers in Anthropology.—Recognizing that the rapid advance of civilization is causing the native races everywhere to disappear, or is modifying them essentially, and that what still exists in its originality must be saved now, the Anthropological Society of Hamburg has framed a schedule of questions, to be sent out to persons who are in a position to answer them intelligently, respecting the more important characteristics of the aborigines of the several countries. The questions concern—first, the names of tribes and the districts in which they live; the color of the tribes, the characteristics of their hair, the material and fashion of their clothing, the ornaments—of whatever kind—they wear, and how they wear them, the marks of paint, cutting, and tattooing, that they put on their skin, whether they file or knock out their teeth; their weapons, how they make them and how they use them, and their de-

fenses; the material, architecture, furnishing, and adornment of their dwellings, whether they be huts, pile-dwellings, caves, or tents; their public buildings, temples, sacred places, and altars; their domestic, hunting, and farming utensils, pottery, glassware, metallic and wooden vessels; how they make and apply their paints; their mining arts; their usages in trade; their money and their manner of counting; how they make their fires; their intoxicants and narcotics; what they know and have of music and musical instruments; what with them takes the place of writing; their superstitions and folk-lore, and particularly the objects to which they give special honors; their social customs and usages in intercourse with friends and enemies; observances in the matters of birth, marriage, and death; their diseases and methods of cure; their ideas as to a future state; their traditions as to their origin; their knowledge of the stars, and their manner of computing time. The questions covering these points in detail are to be sent out, in English and German, to ship-captains, merchants, consuls, and missionaries, who, it is expected, will enter upon the schedule notes embodying such information as they can furnish. As it is impossible to make the questions exhaustive, further communications than those asked for, such as the judgment of the respondent may dictate, will be thankfully received.

An Artificial Volcano.—The newspapers of Cologne tell of a kind of artificial volcano which was produced recently at Apenrade, in the Rhine provinces, in the course of the digging of an artesian well. At the depth of not quite five hundred feet, a strong ebullition was noticed, accompanied by a dull rumbling. Then, all at once, the earth and stones in the tube were violently blown out to a considerable height, with a heavy detonation, and a column of gas came up hissing. When lighted with a match, the gas burned with a clear flame, rising high in the air, till it was extinguished by a new eruption of pebbles and dirt. Eruptions of stones and gas continued till the time the story was told, when the flame of the gas continued to be of undiminished intensity. The phenomenon was occasioned, of course, by one of those accumulations of gas which take place now and then in the bowels of the earth, giving rise to fire-damp explosions in coal-mines, causing earthquake-shocks in countries which are not volcanic, and giving rise to the so-called "mud-volcanoes," when the gas forces its passage through beds of moist clay.

Origin of Native Gold.—Professor J. S. Newberry has presented some strong points of fact and argument against the theory that the grains and nuggets of gold found in placers are formed by precipitation from chemical solutions. He holds, in a paper he has published on the subject, that geology teaches, in regard to the genesis and distribution of gold, that it exists in the oldest known rocks, and has been thence distributed through all strata derived from them; that, in the metamorphosis of these derived rocks, it has been concentrated into segregated quartz-veins by some process not yet understood; that it is a constituent of fissure-veins of all geological ages, where it has been deposited from hot chemical solutions, which have reached deeply buried rocks of various kinds, gathering from them gold with other metallic minerals; and that gold has been accumulated through mechanical agents in placer deposits by the erosion of strata containing auriferous veins.

What has been gained by Vivisection.—Dr. Ferrier was recently arrested in England for practicing vivisection without a license, and the members of the British Medical Association were indignant at the act, regarding it as an insult and a measure of annoyance. Dr. Ferrier's offense seems to have been observing with Dr. Yeo, who had a license, experiments that were intended to throw light upon certain features of the treatment of lesions of the brain. Dr. Ferrier's investigations in this department, which would have been impossible without vivisection, have been of immediate and of the greatest value to mankind. Among the results of them has been the discovery of the means of localizing in its definite region the point where an injury, resulting in epileptic fits, has been inflicted, and of applying remedial treatment to the precise spot where it will be effective. Dr. Echeverria

has given a list of 165 cases of traumatic epilepsy, 64 per cent of which were cured by trephining. Before Dr. Ferrier's experiments this trephining would have had to be done blindly. The knowledge gained by Dr. Ferrier's researches has also been useful in guiding to the spot where pus has accumulated in case of abscesses in the brain, and in indicating the site of tumors. Considering how recently these discoveries have been made, it in fact seems extraordinary that they should have been already productive of so much benefit. The operations on the animals are not painful after the exposure of the brain has been accomplished, and that is done under anæsthetics, nor does any pain follow the recovery from anæsthetic influence. The effects of the after-stimulations are simply the excitement of the wonder and curiosity of the animals at their involuntary motions. Probably a single sportsman inflicts more pain in a day's shooting than Dr. Ferrier has done in the whole course of his researches.

A New Natural Hydrocarbon.—Professor Henry Carvill Lewis has published a description of a new substance resembling dopplerite which has been found in a peat-bog at Scranton, Pennsylvania. It is black, jelly-like in consistency, and elastic to the touch when first taken from the ground, breaking with a conchoidal fracture, but becomes tougher and more elastic, like India-rubber, immediately on exposure to the air. Occasional seeds, having the characters of the spores of one of the higher cryptogams, occur in the substance, as well as in the surrounding peaty matter. The composition of the substance nearly corresponds with the formula $C_{10}H_{22}O_{16}$, differing from that of dopplerite in the presence of much larger proportions of hydrogen and oxygen. Professor Lewis suggests that this product is, perhaps, an intermediate product between peat and coal, and proposes to combine it with dopplerite under the generic name of *phytocollite* ("plant-jelly").

Parasites.—Professor Arnold Heller, of Kiel, has recently published an interesting work on parasites, with particular reference to their import to men. It is only lately that the true origin and character of parasites have been at all adequately understood. Not very long ago they were supposed to be formed out of the substances of the body; and in the condition of knowledge at the time it was hard to account otherwise for their presence in certain parts of the system. They have also been supposed to be received by inheritance; and it has not been fully proved that, in rare instances, this may not be the case. It has, however, been shown that, as a rule, they are introduced into the system, either directly or through germs taken in with the food, breathed in the air, brought by unclean hands or with unclean dishes, or blown in with the dust. They are generally dependent on moisture for their vitality, and, finding in the bodily juices a favorable environment, may become suddenly active after having been long dormant in uncongenial situations. Most, if not all of them, probably existed originally in a free state, and have become wonted to what is now an exclusive abode by gradual adaptation in long time; in such cases, they seem to have lost some of the organs, such as those of locomotion, which they originally possessed, but which have become of no further use to them. Some of them have been made useful to man. The leech serves a valuable purpose in the healing art; the cochineal aphis furnishes a valuable dye; the tape-worm of the snipe tickles the palate of the hunter and the epicure as "maccaroni-piatti"—flat maccaroni; and the worms of fresh-water fishes are esteemed as food in some parts of Italy. The ichneumon flies and their tribe are of inestimable benefit in destroying the insect enemies to vegetation; and helpful moths have been discovered which prey upon the moths and other insects in the furs of rodents and the feathers of birds. Among vegetable parasites, ergot is valuable in medicine, and the mistletoe-berry is used in making bird-lime and fly-paste. It has been suggested that even intestinal worms may be good for children by helping to consume the excess of slime; and Jordan, of Mayence, has set forth that the animals that infest the skin of man may be beneficial by forcing him to look after the cleanliness of his person and clothing, and his intestinal worms by making him careful of his food. This view can not, however, be justified, even when we ad-

mit that parasites in many cases do no perceptible harm. To these cases may be opposed the numerous instances in which they have proved destructive to their hosts, whether animals, birds, or men, often carrying off multitudes of creatures when they become excessively abundant on a species; and in the most favorable cases they give the host discomfort and inconvenience, though their work may be overlooked in the presence of his superior vigor. As a rule, parasites belong to the lower orders of animals—worms or insects. Sometimes an arachnoid or a crustacean will join the company; but a few small fishes are the only creatures among the vertebrates that ever assume that relation. The stories that have been told of the existence of other inhabitants in the system are either fables or have originated in the accidental presence of single individuals who were probably as much astonished as their host at finding themselves in such a home.

The Repeating Melograph.—M. J. Carpentier exhibited, at the recent electrical exhibition in Paris, an instrument called the repeating melograph, by means of which, he claimed, any piece or improvisation which a composer may play on the key-board to which it is attached is registered, and may be repeated upon any other instrument with which it may be connected. It, moreover, secures the repetition, not of the piece only, but of the style, even to the false notes, of the player. Both processes, the registering and the repeating of the piece, are performed through the medium of electric currents. In the former case the keys of the instrument on which the piece is played are connected with wires through which a current is established when the key is pressed down. This current sets in operation an apparatus, with tools answering to the several keys, by means of which a perforation corresponding in character with the musical value of the note is made in a moving band of paper. The piece being finished, the band is ready to serve in a second execution of it. Electric communication is effected between the perforated band and the second instrument; and a current is formed, causing a corresponding key to be sounded at each perforation of the band as it passes the circuit in the process of unrolling. M. Carpentier contemplates adjusting his instrument so that it may also be made to print the piece in ordinary musical type.

Electric Units.—The International Congress of Electricians at Paris unanimously agreed upon a uniform standard of electrical units of measurements. It decided to adopt the fundamental units, the centimetre, the gramme, the second (C. G. S.); that the practical units, the ohm and the volt, should be defined, as now, the ohm as 10^9, and the volt as 10^8; that the unit of resistance (ohm) be represented by a column of mercury having a section of a square millimetre at the freezing-point, and a height to be determined experimentally by the International Committee; that the current produced by a volt in an ohm be called an ampère instead of a weber, the latter name having been applied by Weber himself in Germany to a current of ten times less force; that the name of coulomb be applied to the quantity of electricity defined by the condition that an ampère gives a coulomb a second, the former English weber; and that the name *farad* be applied to the capacity defined by the condition that a coulomb in a farad gives a volt—which is equivalent to the farad of the British Association. The Carcel lamp was recommended to be continued as the standard for the comparison of lights, pending the investigations of an International Committee to ascertain and fix upon the most practicable standard.

"Clouds of Seeds."—A correspondent of "La Nature" describes a remarkable appearance of seeds in the air that was observed in Guatemala during eight consecutive days in February last. In the early hours of the afternoon it was easy to perceive at a certain distance from the ground bodies resembling snow-flakes, which appeared and disappeared instantaneously, generally going in the same direction, but which were visible only when they passed between the sun and the observer. They moved gracefully, with variegated colors, falling and then rising out of sight, as snow-flakes do when they melt in the air; at other times they were carried along by the

wind. The populace thought that fire was falling from the sun. More intelligent persons believed that snow had been actually formed in consequence of the cooling of the atmosphere, some of which had fallen without melting till it came in sight, and this view was currently accepted. It was finally shown, however, that the particles were floating seeds, and every one was enabled to satisfy himself of the fact by grasping a handful of them.

NOTES.

THE tertiary lake-basin at Florissant, between South and Hayden Parks, Colorado, furnishes one of the richest deposits of fossil insects that have been found anywhere. According to Mr. S. H. Scudder, who examined it in connection with the Hayden Survey, it has yielded in a single summer more than double the number of specimens which the famous localities at Œningen, in Bavaria, furnished Heer in thirty years. The Œningen specimens are, however, as a rule, better preserved, but a larger number of satisfactory specimens are found at Florissant than at Œningen. Sixteen species of insects have been published, and, besides these, a planorbis-shell, eight species of fishes, several birds' feathers, and a single tolerably perfect sparrow. Also several thousand specimens of thirty-seven species of plants, have been found.

PROFESSOR NORDENSKIÖLD has had occasion during his Arctic voyages to ask the question, which must have often occurred to many, What becomes of the "self-dead" animals, or those that die a natural death? During his nine expeditions in regions where animal life is abundant, he has found only a very few remains of recent vertebrate animals which could be proved to have died a natural death. We have at present no idea of what becomes of the bodies of such animals, "and yet we have here a problem of immense importance for the answering of a large number of questions concerning the formation of fossiliferous strata. It is strange, in any case, that on Spitzbergen it is easier to find the vertebræ of a gigantic lizard of the Trias than bones of a self-dead seal, walrus, or bird, and the same also holds good of more southerly inhabited lands."

MR. A. S. PACKARD, JR., has given, in a contribution to the Boston Society of Natural History, the descriptions of twenty-two new species of ichneumon, microgaster, tricogramma, and other genera of parasites infesting North American butterflies, typical specimens of most of which may be seen in the collection of Mr. S. H. Scudder, and of a few in the Harris collection of the museum of the society.

PROFESSOR OTIS T. MASON is not satisfied with the existing classifications of the anthropological sciences, and has adopted a classification of his own, as follows: 1. Anthropogeny; 2. Prehistoric Anthropology; 3. Biological Anthropology; 4. Psychological Anthropology; 5. Ethnology; 6. Linguistic Anthropology; 7. Industrial Anthropology; 8. Sociology proper; 9. The Science of Religion; to which he adds a tenth class of works on the instrumentalities of research. In his bibliographical contributions to the Smithsonian Report and the "American Naturalist," Professor Mason states that a larger number of papers have been published on prehistoric anthropology than on any other branch of the science. He enumerates one hundred and forty-six memoirs in this branch as published in 1879, and twenty-eight as published in America alone in 1880.

THE deaths in the Peabody Buildings, London, during sixteen years, have been at the rate of sixteen and seven tenths per thousand per annum, while the general death-rate of the metropolis during the same period has been twenty-three and four tenths. The death-rate in the crowded districts surrounding the Peabody Buildings has been stated to be thirty or forty to the thousand.

A COMMITTEE of the British Association is investigating the question of the existence of earth-tides, or of oscillations in the crust of the earth similar to those which are produced in the ocean by the attraction of the moon. A pendulum is so suspended that its slightest motion turns a mirror, and causes a perceptible movement in the spot of light reflected by it upon a distant screen. The pendulum is proved to be continually changing its position, for the reflected light is in incessant motion, and so irregularly that it is hardly possible to localize its mean position on the screen within five or six inches. Mr. W. Mattieu Williams has suggested that the constant movements of the microscopic bubbles imprisoned within the cavities of gems and minerals are due to the same cause.

THE death is announced of the Rev. Dr. Thomas R. Robinson, Director of the Observatory at Armagh, Ireland. He was elected to the Royal Society in 1856, and was one of the oldest Fellows on the list, being nearly ninety when he died. His latest contribution to science, "On the Constants of the Cup Anemometer," was published in the "Philosophical Transactions" in 1880.

M. P. PUISEUX, remarking upon the apparent relations between the activity of vegetation and actinometric conditions, cites in illustration the promptitude with which plants mature during the summer of lands which the snow hardly leaves. Phanerogamous plants may be found at the height of twelve thousand feet, ranunculuses on the Schreckhorn, saxifrages on the Gravola, going through all the phases of their development in the space of three months under a mean temperature, according to ordinary estimates, considerably inferior to that of the polar regions. Doubtless these plants find a compensation for the unfavorable thermic conditions in the intensity of the solar radiation at great altitudes, which is increased by the reflections from the snow.

M. GAUTIER insists, in a number of communications to the French Academy of Sciences, that the venom of serpents contains a toxic substance analogous to the alkaloids and the ptomaïnes. The venom of the *Vaja tripudians*, of which a quarter of a milligramme will kill a sparrow, may be boiled, filtered, and treated with alcohol, without losing its activity. These properties indicate a relation with the alkaloids. Not only the saliva of serpents, the salivas of other animals—of the dog, the hare, even of man—are capable of exhibiting deleterious properties. An extract from human saliva furnishes an extremely poisonous liquid, capable of killing a bird almost as quickly as the venom of a serpent. Thus the saliva of man, the dog, and the serpent, all contain toxic alkaloids, and do not differ essentially except in the higher or lower degree of concentration of the poison; and it appears that animal as well as vegetable tissues are capable of elaborating alkaloids.

M. G. DELAUNAY has been studying the influence exercised by the greater or less intensity of the nutritive phenomena in cases of poisoning by strychnine. Equal doses of strychnine were given to two frogs, one of which had been kept active for a half-hour previously. The poison took effect more quickly and more actively upon this one than upon the one that had been quiet. In another experiment, the poison operated more slowly and more lightly upon a frog that had been bled than upon the other one, which had not been hurt. When one of the frogs was bled after taking the poison, it exhibited a tendency to return to the normal condition in measure as it lost blood.

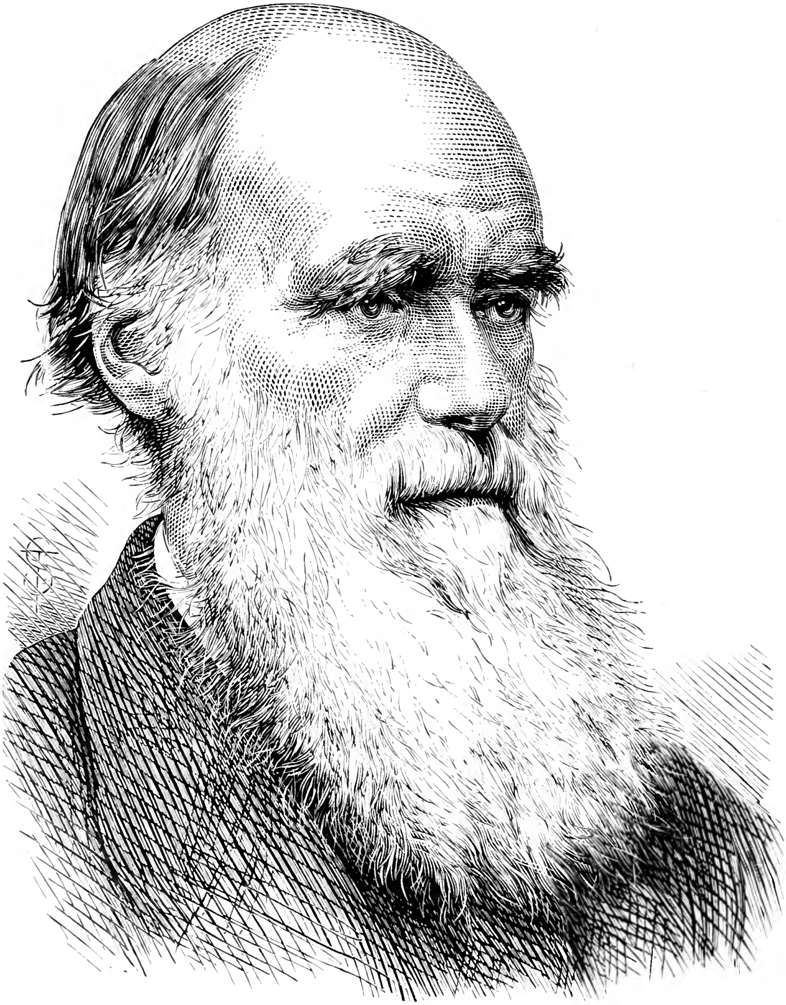
M. ALBERT GAUDRY has been elected to fill the chair in the French Academy which was made vacant by the death of M. Sainte-Claire Deville, receiving forty votes to eighteen cast for his competitor, M. Laury, geologist. "La Nature" remarks that with M. Gaudry a new science, paleontology, obtains representation in the institute.

DR. K. VON FRITSCH, of Halle, maintains that the causes of earthquakes are much slighter than has been generally believed, that they may be sought at a depth of not more than ten or fourteen miles, and often of less, and that rather feeble forces may produce earthquakes which will be felt at great distances. The hammer in Krupp's factory, which weighs a thousand centners, and falls from a height of ten feet, produces sensible concussions over a surface five miles in diameter; and a recent explosion in a dynamite factory was felt at between twenty-five and thirty miles away. Dr. Fritsch points out how earthquakes might and must be produced by the increase and decrease in volume of rocks under the influence of physical and chemical forces, by concussions, by the opening of crevices in rocks, and by the subsidence of masses of rocks due to these agencies.

DR. S. GIBBON, medical officer for the Holborn district, London, says in his latest report that, whatever may be the cause, there is no doubt that a Jew's life in London is, on an average, worth twice as many years as a Christian's. The Hebrews of the metropolis are notoriously exempt from tubercular and scrofulous taint. Pulmonary consumption is very rare among them. The medical officer of one of the Jewish schools has remarked that their children do not die in anything like the same ratio as Christian children. In High Street, Whitechapel, the average death-rate on the north side, which is occupied by Jews, is twenty per thousand, while on the south side, which is occupied by English and Irish Gentiles, it is forty-three per thousand.

MR. C. R. PLOWRIGHT, F. L. S., made thirteen experiments last summer in inoculating wheat-plants with the fungus of the barberry-bush, and derived results adverse to the theory that wheat-mildew is developed from the fungus. One hundred and seventy-six plants of wheat were employed, seventy-eight of which were inoculated with the barberry-fungus, and ninety-eight uninoculated ones were kept for check plants. Seventy-six per cent of the inoculated plants developed the rust in about fifteen days, and seventy per cent of the uninoculated plants developed it also. Only one experiment of the thirteen seemed to support the theory of metamorphosis.

MR. MUYBRIDGE has been exhibiting some remarkable rapid-process photographs in Paris, one of which is said to have been taken in one hundredth of a second. He has obtained a series of six photographs during the leap of a clown, which when projected on a screen by a zöetrope exhibit the clown as in motion, with all his changes of position.



CHARLES DARWIN, M. A., F. R. S., Etc.

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SPECULATIVE SCIENCE.

By J. B. STALLO.

"*Wenn ein Kopf und ein Buch zusammenstossen, und es klingt hohl, muss es denn immer das Buch gewesen sein?*"—LICHTENBERG, *the Physicist.*

THE above title is prefixed to an article contributed by Professor Simon Newcomb to the April number of the "International Review." The avowed object of that article is to discredit a recent volume of the "International Scientific Series" ("The Concepts and Theories of Modern Physics") as a publication unworthy of the company in which it appears, and to denounce its author as a person ignorant of the subject whereon he writes—as a scientific, or rather unscientific, "charlatan" and "pretender" belonging to the class of "paradoxers" whom Professor De Morgan has immortalized in his famous "Budget." I am fully aware that, as a rule, it is both unwise and in questionable taste for an author to make direct reply to criticism, however hostile, baseless, or absurd. The merits of a book must find their vindication, at last, in its contents, and the chief function of the critic is to bring them to the attention of the reader, the value and spirit of the critical performance being of secondary importance. But the case in hand appears to me to be an exceptional one. The unmistakable intent of Professor Newcomb's "criticism" (and, if it be left unchallenged, its probable effect) is to signalize the contents of the book with which he deals as mere drivel, and unworthy of a moment's serious attention. And he writes for a magazine, the majority of whose readers, however intelligent they may be, can hardly be expected to possess that familiarity with the matters under discussion which is a necessary prerequisite to the formation of an independent and trustworthy judgment. All they are likely to know and care is,

that Professor Newcomb is a prominent scientist, at the head of a scientific bureau in Washington; while the author of the book he professes to review, if known at all, is known only in connection with pursuits which are generally supposed to preclude, not only distinction but even reputable standing in the domains of scientific investigation. I take the liberty, therefore, to subject the strictures of my critic to a counter-critical examination, trusting that the learned professor himself will find it thorough, and that the reader who has not only perused his article, but also looked into a chapter or two of my book, will recognize it as neither impertinent nor unfair.

Whatever may be thought of the soundness or unsoundness of the general argument of the little book in question, the drift of that argument, it seems to me, can hardly be mistaken by the reasonably intelligent reader. What I attempt to show is simply this: that modern physical science aims at a mechanical interpretation of physical phenomena, seeking to effect a reduction of them to two elements which are ordinarily designated as *matter* and *motion*, but which (for reasons briefly stated in the book, but to be stated more at length presently) are more correctly designated as *mass* and *motion*. I then attempt to show that, if to these premises we add the assumption of the atomic constitution of matter, the mechanical theory necessarily involves four distinct propositions, relating severally to the equality, inertia, and inelasticity of the atoms or ultimate molecules and the essentially kinetic character of what is now universally termed energy. In order to enforce the irrecusability of these propositions on the basis of the atomo-mechanical theory, and to guard against the imputation that I am engaged in the frivolous pastime of chopping logic, I am at pains to show, in the next four chapters, that every one of these propositions is insisted on and propounded in terms identical with, or equivalent to, those in which I state them, by men whom I was under the delusion, up to the time of the appearance of Professor Newcomb's article, of regarding as persons of the highest scientific authority—such men as Professors Du Bois-Reymond, Thomas Graham, Wundt, etc. I then proceed to inquire what is the relation of these propositions to the sciences of chemistry, physics, and astronomy, as they are actually constituted, endeavoring to ascertain whether or not the fundamental propositions of the atomo-mechanical theory are available as theoretical solvents of the facts with which these sciences are conversant, and whether or not they are consistent with them. The result of this inquiry is, that the man of science, however emphatic he may be in the general assertion that all physical phenomena are due to the interaction of atoms or ultimate molecules, is constrained by the data of scientific experience to repudiate and discard the propositions which his assertion necessarily involves. It thus appears that there is conflict between the facts and working hypotheses or theories of the sciences on the one hand and the atomo-mechanical theory on the

other; that the latter theory fails in the presence of the facts, and that all attempts to remove this conflict have, thus far at least, been abortive.

After supplementing these preliminaries by a discussion of the atomic theory and its dependant, the kinetic theory of gases, I approach the problem whose solution is the sole aim of my little treatise, which, as is expressly stated in the very first sentence of the preface, is designed as a contribution, not to physics or metaphysics, but to the theory of cognition. That problem is the determination of the logical and psychological origin of the mechanical theory, and of its attitude toward the laws of thought and the forms and conditions of its evolution. It is neither necessary nor practicable here to attempt a reproduction of the tenor of my discussion. It is sufficient for my present purpose to state my conclusion, which is, that the mechanical theory with all its implications is founded on a total disregard or misapprehension of the true relation of thoughts to things or of concepts to physical realities; that, so far from being a departure from and standing in antagonism to metaphysical speculation, the propositions which lie at its base are simply exemplifications of the fallacies that vitiate all metaphysical or ontological reasoning properly so called. There is hardly a page in the book, after the first two expository chapters, in which my utter repudiation of the mechanical theory and its fundamental assumptions is not conspicuous. My objections to this theory are stated in so many ways, and are enforced by so many considerations, that my position in regard to it appears to me insusceptible of misapprehension even by the most hebetated intellect. During the last six weeks I have received more than twenty letters from various persons—most of them mathematicians and physicists, but a few of them persons without scientific training—in which the doctrines of my book are discussed or questioned, sometimes on grounds which indicate that my meaning has been strangely misapprehended. But not one of these letters gives rise to the least suspicion that the writer was mistaken as to my attitude toward the mechanical theory.

And now, what does Professor Newcomb represent my position to be? The reader who has not seen his article will be amazed when I tell him that, according to him, my book was written for the purpose of *maintaining* the propositions of the atomo-mechanical theory, and of subverting the whole science of physics by means of them, on the principle, I suppose, that if the facts do not agree with the theory, so much the worse for the facts! Here is Professor Newcomb's language:

> The author's criticism is wholly destructive; where he constructs it is only to destroy. It is true that his first chapter on the atomo-mechanical theory lays down certain propositions already mentioned which he seems to hold as true. He makes use of them to destroy the whole fabric of modern physics, and show physical investigators generally to be the subjects of miserable delusions. But

his last chapter is devoted to showing that this theory is itself a failure, so that, when he takes his leave, we have nothing left to contemplate but a mass of ruins.

It is curious to note the introduction of the word "seems" into this passage—as the lawyers say, its appearance with a *semble*—while in other places, e. g., where Professor Newcomb speaks of the proposition that molecules are inelastic as my "favorite doctrine," or where he charges me (after reading my tenth chapter!) with ignorantly confounding the "abstract noun" *mass* with the concrete term *matter*, he makes no such qualification.

Having satisfied himself (no doubt before writing his article, though the conclusion is stated most explicitly toward its close) that I am in the lists as a champion of the atomo-mechanical theory and as the dogmatic defender of its fundamental propositions, he proceeds to assail these propositions, sometimes with what he seems to regard as an argument, but generally with a sneer. The contents of my introductory chapter, consisting almost exclusively of citations from the writings of Professors Kirchhoff, Helmholtz, Clerk Maxwell, Ludwig, Du Bois-Reymond, etc., he brands as "propositions in which we can trace neither coherence nor sense." The thesis that, on the basis of the atomo-mechanical theory, all potential energy is in reality kinetic—the distinct proposition of Professor P. G. Tait, who asserts it as the unavoidable consequence of the atomo-mechanical theory of gravitation—he "passes over as not even worth quoting." Similarly the doctrine of the essential passivity of matter—also a proposition of Professor Tait, whose exact words I quote on page 306 of my book—is flouted with the disdainful remark that "such words as 'active' and 'passive' have no application in the case and serve no purpose, except to produce confusion in the mind of the reader." In this way he levels his thrusts at the most eminent physicists and mathematicians of the day, laboring always under the hallucination that he is striking at me.

Among the most characteristic performances of Professor Newcomb are his strictures, already adverted to, on my substitution of the term *mass* for the word *matter*, in designation of the substratum of motion in the light of the atomo-mechanical theory. According to him, this use of the word *mass* is evidence of my ignorance and intellectual confusion, as well as of my "total misconception of the ideas and methods of modern science." He informs me that the word *mass* is "an abstract noun like *length*," whereas I use it "as a concrete term, and in *nearly* the same sense as we commonly use the word matter." And thereupon he delivers himself of a dissertation (which resembles nothing so much as a sermon of "Fray Gerundio" to his "familiars") on the necessity of using scientific terms only in accordance with their exact definitions, of ascertaining the meanings of the words *mass* and *motion* by a reference to the methods whereby they are measured, and

so on. All this is certainly strange news to an author who has devoted several chapters of his book to the task of showing that the great fundamental vice of the mechanical theory is the confusion of concepts with things, and particularly of the connotations of the concept *mass* with the complement of the properties of *matter*—who, in a word, is guilty of the great offense of expressing, in the precise terms of the science of logic, what Professor Newcomb is staggering at with a phrase borrowed from some elementary treatise on grammar!

And here I am tempted to do a little Gerundian preaching myself, Professor Newcomb being, of course, my congregation of "familiars." Here is my sermon: *Hombre sabio y admirado*, scattering supernal wisdom, like hurling thunder-bolts, is a prerogative of the dwellers on Olympus, not to be usurped by a drag-footed philosopher bellowing at its base. *Quod licet Jovi, non licet bovi.* I do not mean to question your general ruminant powers; but you have delivered yourself of some things "that have not been well digested," and had better be chewed again. Let me see how I can help you. Listen: When we speak of matter, we mean something which not only has weight, proportional to its mass, but which has all manner of properties—optic, thermic, electric, magnetic, chemical, and so on. Now, in the light of modern science, all these "properties" are regarded as *modes of motion*, if I may be permitted to use the expression of Professor Tyndall. And when we strip matter (in thought, you understand) of all these modes of motion, we have nothing left but *inertia*, which is but another name for mass. This mass is not a concrete thing, but a concept or a part of a concept; it is, as you say, "an abstract noun like length." And the trouble with the atomo-mechanical theorists is their fancy that this abstraction is a thing in itself, something you could look at if you had a telescope with sufficient magnifying power, or which you could weigh and measure if you had a pair of scales or a chemical reagent sufficiently delicate. They labor, as you see, under a huge mistake, which, in charity, ought to be corrected. Whenever you find real matter, you have *mass* and the modes of motion in indissoluble synthesis and conjunction. But when this synthesis is broken by the destructive analysis of the mechanical theorist who persists in saying that things consist of *matter* and motion, you are bound to tell him that what he calls *matter* is not matter at all, but only something which, by a curious law of our thought, we are bound to conceive or imagine as a substratum of motion—the word *substratum* being a barbarous Latin term which in a rough way signifies what is supposed to underlie motion. The term *matter*, as used by those deluded people who think that all the facts of this world can be explained by a resolution of them into matter and energy, or matter and motion, denotes simply what the physicist who knows what he is talking about calls *mass*.

And now, mind, what I have just told you is not some shallow con-

ceit hatched under my own time-tonsured pate, but genuine wisdom which I have simply borrowed from an old, clear-headed fellow, who lived and died a long while ago—Leonhard Euler. If you will read his seventy-fourth letter to a German princess, written on the 11th day of November, 1760, you will find it all set forth at great length. In reading it you must bear in mind, though, that in Euler's time the imponderables, as they were then called, were not so distinctly known or believed to be modes of motion as they are now. And you must also remember that he was writing to a princess who probably knew more about madrigals and operatic airs than about scientific terms, in consequence whereof his exposition became a little diffuse. If, however, you should reject old Euler's reasoning as "belonging to a past age of thought," which, I see, is one of your favorite ways of getting rid of irrefutable truths, I may refer you to a gentleman who is yet among the living—Hermann Helmholtz. You will find what he has to say on the "matter in hand," on the third and fourth pages of his first essay, "Ueber die Erhaltung der Kraft" (not included in the collection of his essays).

Now, *hombre querido* (I am still preaching), if after this you will carefully read again the first twelve chapters of my book, you will probably find that they are somewhat less absurd than you fancied they were. But you will say, no doubt—in fact, you *do* say, though not in so many words—that all this is mere speculative trash, in which the man of science has no concern. One of my reviewers in the New York "Critic"—whom I at one time suspected, perhaps unjustly, from certain peculiarities of his phraseology, and from the fact that, like yourself, he sneers at me for having "wasted" two long chapters on transcendental geometry, of having had oral confabulations with you, in which the mouth of the speaker was not and could not be applied to the ear of the listener—disposes of my discussion of the relation of the mechanical theory to the laws of thought by the following oracular dictum (a travesty of a saying of Carlyle): "A sound digestion has little self-consciousness of the operations of the stomach; the sound thinker gives himself little uneasiness respecting the laws of thought." I can not stop, at this moment, to show you how and why a little knowledge of the laws of thought is useful to the physicist and mathematician. I shall come to that by-and-by, when I have considered what you say about the kinetic theory of gases and space of an indefinite number of dimensions. For the present I only want to tell you how I ventured upon the audacity of intruding the theory of cognition into the science of physics.

In Europe, as well as in this country, there are certain idle fellows who, during the first half of the present century, for want of more useful occupation, took to tracing the ramifications of forms of speech, and finally got to digging for their roots. These absurd persons abound chiefly in Germany, where, as you know, the people are always

in the nebular regions, when they ought to be fighting and grubbing on the solid ground below. In course of time these individuals, despite the utter fatuity of their undertaking, persuaded themselves that they were engaged in something important, and became noisy and presumptuous. At one time they even clamored for admission into the ranks of the physicists and astronomers, on the ground that they had discovered phonetic and other laws, which they claimed to be as immutable as the laws of Kepler. Their application was, of course, scornfully denied, for the reason that they were either no scientists at all, or at best speculative scientists. Instead of submitting humbly to this just decree of the physicists (it is a pity they had not my present meekness before them as an example), these men grew wrathy and turned away with something like this objurgation : "Well, never mind, the time is not far distant when you will come as suppliants to us." And, thereupon, in sheer malice, having got well-nigh through with the roots and branches of words, they fell to attacking the history of their meanings—of concepts, as they called them—pretending to make legitimate employment of inductive methods, which they wholly misapprehended, no doubt, and which, at any rate, were among the clear prerogatives of the physicists. And now they pretend to have established, *inductively*, a number of laws relating to the operations of the intellect, which they again assert to be immutable, and, though controlling acts of consciousness, to be wholly independent of deliberate intent or set purpose. They say, for instance, that there runs throughout the history of speculative as well as of ordinary thinking an almost irrepressible tendency to hypostasize concepts, or (as I have called it, cribbing an outrageous barbarism from Professor Bain) to *reify* them. I will try to explain to you what that means, as nearly as possible in your own words. When people make or find a new "abstract noun," they instantly try to put it on a shelf or into a box, as though it were a thing ; thus they *reify* it. In very early times they did worse than that—they undertook to incase it in a smock-frock or a pair of breeches. They *personified* it. There was a still earlier period when, worst of all, men blasphemously and impiously *deified* abstractions ; and it is said that this class of persons has not wholly died out yet.

Now, the silly speculators I have just alluded to have already divided the science they pretend to be cultivating into several branches, to which, being word-mongers, they give all sorts of sesquipedalian names, such as comparative linguistics, comparative psychology, comparative mythology, and so forth. To give you an idea of the temerity of these pseudo-scientists, let me tell you that one of them, Professor Max Müller, of Oxford—who is, of course, a German—at one time undertook to account for the monotheism of the Jewish race by a peculiarity of Semitic speech. It is even whispered that he and others, years ago, evolved the whole city of Troy, with all its houses and

walls, the heroes within it, with their wives and children, as well as the Greek warriors and their ships, without it—everything, including the Trojan horse and what it contained—from a parcel of solar myths, demonstrating to their own satisfaction that all these persons and things were, at bottom, nothing more than "objectivations" of forms and laws of speech. As was to be expected, this fine theory came to grief when Schliemann appeared with a pickaxe and spade. As usual, the theory collapsed in the presence of the facts. Be that as it may, there is one thing these scientific pretenders persist in asserting, in spite of all their past discomfitures: that more than three fourths of the controversies in theology and metaphysics have had their rise in the ignorance of the fathers of the Church, and of mediæval and modern scholastics, of the results brought to light in these new-fangled sciences. Unfortunately, when I was less old and wary than I am now, I fell in with these "paradoxers," some of whom I knew to be men of great learning, and believed to be persons of thorough earnestness of purpose. To my astonishment I found two mathematicians among them—Hermann Grassmann and Franz Woepcke. I had read with some difficulty, but, as I thought, with reasonable grasp of his meaning, the "Ausdehnungslehre" (since supplemented by a new treatise under nearly the same title, and a number of articles in Crelle's and Borchardt's "Journal") of Grassmann; and I had attempted to read some of the writings of Woepcke, though without success, because he went far beyond my depth. But I got an impression that both had things to say—in mathematics, at least—that were worth knowing; and inferred that there must be sense and purpose also in their linguistic endeavors. In this way I became interested, and gradually caught the spirit of the comparative linguists and mythologists by contagion. And so it came to pass that, after a while, I asked myself this question: "If the results of these sciences are available for the solution of the perplexities of the metaphysicians, why may they not also throw some light on the nature of our perplexities in physics?" So far as I could learn, no one had attempted an orderly and systematic answer to this question, although (as is not unusual in cases of this sort) there was a considerable amount of scattered material ready to the hand of whomsoever should undertake the work. Under these circumstances, I was fool-hardy enough to make an attempt myself, the result being my poor little book. And now I confess I am not a little mortified at being informed that I am a "learned and able" idiot; and I derive but scant comfort from the assurance that my mental predicament may be accounted for on the theory of contagion, and that the hypothesis of congenital imbecility may be avoided.

But it is time to doff my Gerundian robes and to cease apostrophizing the familiars, for I have things to say which ought to be said in all earnestness and sobriety. I am about to examine Professor

Newcomb's animadversions on my chapters on the kinetic theory of gases and transcendental geometry. On the former he expatiates as follows:

For the benefit of the non-scientific reader we may say that there is no theory of modern physics, the processes supposed by which are invisible to direct vision, which is more thoroughly established than this. It explains with the utmost simplicity and without introducing any but the best known properties of molecules, a great number of diverse phenomena, seemingly incapable of explanation in any other way. The only objection of the author which we can completely understand is that the theory in question—i. e., the kinetic theory of gases—seems to him incompatible with his own favorite doctrine that molecules are inelastic. Should he have any hesitation in pitting his *a priori* idea against so widely received a theory, it should relieve him to know that the supposed antagonism arises only from his own misapprehension. *No elasticity is assigned the molecules in the kinetic theory, but only an insuperable, repulsive force which causes the molecules to repel each other when they are brought sufficiently near together.* The reader who has any interest in following the author in his attempt to show that Maxwell and his colaborers were guilty of a long series of fallacies and errors in attempting to prove the theory in question, may read the chapter, as an abstract is impossible.

So "no elasticity is assigned to the molecules in the kinetic theory." Well, that is startling news indeed! I hope it has been conveyed to Sir William Thomson, who at latest accounts was still engaged in the arduous, but, as we are now informed by Professor Newcomb, utterly useless study of vortex-rings, which he hopes to make available as substitutes for elastic atoms or ultimate molecules. At the last meeting of the British Association Sir William Thomson read a paper "On the Average Pressure due to the Impulse of Vortex-Rings on a Solid," of which an abstract is published in "Nature" for May 12, 1881 (vol. xxiv, pp. 47, 48). In this paper Sir William says:

The pressure exerted by a gas composed of vortex-atoms is exactly the same as is given by the ordinary kinetic theory, *which regards the atoms as hard elastic particles.*

I do not deem it necessary to multiply quotations from the writings of other scientific men in support of my statement that the kinetic theory of gases can not dispense with the assumption of the elasticity of ultimate molecules. No intelligent reader who has glanced at page 42 of my book can be in any doubt as to what is taught on the subject by the founders and promoters of the theory in question. But I will add one citation, because it is from a book to which I shall have occasion to refer for another purpose. The most thorough mathematical treatise on the kinetic theory of gases, indorsed as such by Clerk Maxwell, is the well-known little book of Henry William Watson. It is in the form of propositions; and the very first words of the first proposition are these:

A very great number of smooth, *elastic* spheres, equal in every respect, are in motion within a region of space of a given volume, and therefore occasionally impinge upon each other with various degrees of relative velocity, and in various directions.

The italics in this passage, as well as in all past and future quotations, are mine.

In justice to Professor Newcomb, however, we must look at his entire sentence, which is this: "No elasticity is assigned to the molecules in the kinetic theory, *but only an insuperable, repulsive force, which causes the molecules to repel each other when they are brought sufficiently near together.*" This information, Professor Newcomb hopes, will "relieve me." I am indeed relieved! What the learned professor tells me in the last part of his sentence certainly simplifies matters to the last degree. All that needs be assigned to the molecules is an "insuperable repulsive force." Such a force is the greatest convenience for the physicist that can possibly be devised; it not only effects a simple and satisfactory solution of the difficulties set forth in my fourth and eighth chapters, but it enables us at once to get over every other difficulty that may be suggested. It is singular that Sir Isaac Newton did not understand this when he was distressed about the mechanism of gravitation; for, obviously, all that is required to explain it is to assign to the molecules an *attractive force.* Sir Isaac's ignorance is all the more remarkable because, coming to think of it, I now recollect that the philosophy of which Professor Newcomb is the able exponent was very clearly set forth, just fourteen years before the appearance of Newton's "Principia," in a profound metaphysical treatise published by one Jean-Baptiste Poquelin (otherwise called Molière) under the somewhat whimsical title "Le Malade Imaginaire." Toward the close of that great work (which is in the form of dialogues), one of the interlocutors, Bachelierus, philosophizes as follows:

"Mihi a docto doctore
Domandatur causam et rationem quare
Opium facit dormire.
A quoi respondeo
Quia est in eo
Virtus dormitiva
Cujus est natura
Sensus assoupire."

Of course, we are not to be embarrassed by anything John Bernoulli has written about "insuperable forces" as mathematical or physical functions; nor is it worth while to be disturbed by considerations respecting the effect of their assumption upon the doctrine of the conservation of energy.

Professor Newcomb's indignation at my treatment of the kinetic theory of gases is very great indeed. "There is no theory of modern physics," he says, "the processes supposed by which are invisible to

direct vision, which is more thoroughly established than this. *It explains with the utmost simplicity, and without introducing any but the best-known properties of molecules, a great number of diverse phenomena seemingly incapable of explanation in any other way.*" Now, it is a great pity that these glad tidings did not reach Professor Clerk Maxwell before he was laid to rest in his early grave. They would certainly have been a great comfort to him, and possibly might have prolonged his life. For there is reason to suspect that in his latter days he arrived at conclusions respecting the kinetic theory of gases which bear a strange resemblance to my own. Being, not a scientific dogmatist, but an honest and candid investigator in search of truth, he came to see with ever-increasing clearness that the difficulties of his favorite theory beset not only its fundamental assumptions, but also their inevitable consequences, especially in their bearings upon the theory of heat. After the appearance of Watson's treatise already adverted to, on the 26th day of July, 1877, he published in "Nature" (vol. xvi, No. 404) a review of it, in which he considered the significance of Mr. Watson's propositions in connection with certain matters discussed on pages 97, 99, and 127 of my book. And thereupon he made this declaration ("Nature," vol. xvi, p. 245) :

> The clear way in which Mr. Watson has demonstrated these propositions leaves us no escape from the terrible generality of his results. Some of these, no doubt, are very satisfactory to us in our present state of opinion about the constitution of bodies, but there are others which are likely to startle us out of our complacency, *and perhaps ultimately to drive us out of all the hypotheses in which hitherto we have found refuge into that state of conscious ignorance which is the prelude to every real advance in knowledge.*

I hope, by-the-way, that this last remark of the great scientist will be pondered by those who complain that, after demolishing, as they imagine, all current physical theories, I leave them in the midst of ruins, and do not at once present them with a golden key for unlocking all the mysteries of the universe, or, like Puck, in "Midsummer-Night's Dream," "put a [theoretical] girdle round about the earth in forty minutes."

Before I leave this subject, I take the liberty of quoting another passage from the same article, which Professor Newcomb, if he knows *anything* about the discussions to which the kinetic theory of gases has given rise, will find instructive. Speaking of Boltzmann's attempt to reconcile the elasticity of atoms with their rigidity by increasing their co-efficients of elasticity *ad infinitum*, so as to make them practically rigid—a supposition also developed in an essay of Hugo Fritsch in Königsberg, entitled "Stoss zweier Massen unter der Voraussetzung ihrer Undurchdringlichkeit behandelt," which does not seem to have fallen under Professor Maxwell's notice (and, I may add, a supposition of which Professor Newcomb's "insuperable force" may

be a vague reminiscence)—Maxwell says ("Nature," vol. xvi, pp. 245, 246):

But, before we accept this somewhat promising hypothesis, let us try to construct a rigid-elastic body. *It will not do to increase the co-efficients of elasticity without limit till the body becomes practically rigid.* For such a body, though apparently rigid, is in reality capable of internal vibrations, and these of an infinite variety of types, so that the body has an infinite number of degrees of freedom.

The same objection applies to all atoms constructed of continuous, non-rigid matter, such as the vortex-atoms of Thomson. Such atoms would soon convert all their energy of agitation into internal energy, and the specific heat of a substance composed of them would be infinite.

A truly rigid-elastic body is one whose encounters with similar bodies take place as if both were elastic, but which is not capable of being set into a state of internal vibration. We must take a perfectly rigid body and endow it with the power of repelling all other bodies, but only when they come within a very short distance from its surface, but then so strongly that under no circumstances whatever can any body come into actual contact with it.

This appears to be the only constitution we can imagine for a rigid-elastic body. And, now that we have got it, the best thing we can do is to get rid of the rigid nucleus altogether, and substitute for it an atom of Boscovich—a mathematical point endowed with mass and with powers of acting at a distance on other atoms.

But Boltzmann's molecules are not absolutely rigid. He admits that they vibrate after collisions, and that their vibrations are of several different types, as the spectroscope tells us. But still he tries to make us believe that these vibrations are of small importance as regards the principal part of the motion of the molecules. He compares them to billiard-balls, which, when they strike each other, vibrate for a short time, but soon give up the energy of their vibration to the air, which carries far and wide the sound of the click of the balls.

In like manner, the light emitted by the molecules shows that their internal vibrations after each collision are quickly given up to the luminiferous ether. If we were to suppose that at ordinary temperatures the collisions are not severe enough to produce any internal vibrations, and that these occur only at temperatures like that of the electric spark, at which we can not make measurements of specific heat, we might, perhaps, reconcile the spectroscopic results with what we know about specific heat.

But the fixed position of the bright lines of a gas shows that the vibrations are isochronous, and therefore that the forces which they call into play vary directly as the relative displacements, and, if this be the character of the forces, all impacts, however slight, will produce vibrations. Besides this, even at ordinary temperatures, in certain gases, such as iodine gas and nitrous acid, absorption bands exist, which indicate that the molecules are set into internal vibration by the incident light. The molecules, therefore, are capable, as Boltzmann points out, of exchanging energy with the ether. But we can not force the ether into the service of our theory so as to take from the molecules their energy of internal vibration, and give it back to them as energy of translation. It can not in any way interfere with the ratio between these two kinds of energy which Boltzmann himself has established. All it can do is to take up its own due proportion of energy according to the number of its degrees of freedom. We leave it

to the authors of "The Unseen Universe" to follow out the consequences of this statement.

I may safely take it for granted after this, I presume, that, while Professor Newcomb may have a vocation for expounding and defending the kinetic theory of gases, he has no special call, as he supposes, to stand up for Clerk Maxwell and his opinions.

It is hardly necessary to say that Professor Newcomb does not honor my objections to the kinetic theory of gases with any notice or attempt at refutation. He observes that "an abstract of them is impossible," which is to be regretted, for, if he had undertaken to give us one, we should undoubtedly have learned some noteworthy things. The task of making such an abstract does not appear to be very difficult. What I insist on is, that every valid physical theory is essentially a simplification and not a complication, a reduction of the number of unrelated facts which it undertakes to account for, and not a mere substitution of many arbitrary assumptions of unknown and unverifiable facts for a few known facts—that is to say, speaking in the language of mathematics, that every true physical theory is in effect a reduction of the number of independent variables representing the phenomena to be explained. And I show that the kinetic theory of gases not only fails to satisfy this requirement, but is a complete reversal of a legitimate scientific procedure. This is the sense of the passage which Professor Newcomb parades before the unwary reader, whom he ought to have shocked still more with my horrible suggestion (which I now deliberately repeat) that a gas is in its nature a simpler thing than a solid, and that no attempt to account for its properties by taking those of a solid as a basis and making arbitrary additions to them is likely ever to succeed.

It is not a little instructive to note the character of sacredness ascribed by persons of Professor Newcomb's frame of mind to dominant physical theories, and the violence with which they repel every attempt to point out their defects. My reviewer in "The Critic" is almost beside himself after reading my "assault" on "that magnificent fabric of science, the undulatory theory of light and heat." Before he pelts me again with his missiles, he will do well to look and see who is standing at the place to which he directs them. There is at Harvard University a most learned and laborious scientist whose merits as an original investigator are at least equal, if not superior, to his inestimable services as an expounder of scientific truth, and the extent of whose attainments is no less conspicuous in his memoirs and books than the clearness of his intellect—Professor Josiah P. Cooke, Jr. In May, 1878, Professor Cooke published a lecture on the radiometer in this journal ("Popular Science Monthly"), in which he had occasion to speak of the undulatory theory of light and the luminiferous ether. And there (pages 11, 12) we find this language:

But turn now to the astronomers, and learn what they have to tell us in re-

gard to the assumed luminiferous ether through which all this energy is supposed to be transmitted. Our planet is rushing in its orbit around the sun at an average rate of over 1,000 miles a minute, and makes its annual journey of some 550,000,000 miles in 365 days, 6 hours, 9 seconds, and $\frac{6}{10}$ of a second. Mark the tenths; for astronomical observations are so accurate that, if the length of the year varied permanently by the tenth of a second, we should know it; and you can readily understand that, if there were a medium in space which offered as much resistance to the motion of the earth as would gossamer threads to a race-horse, the planet could never come up to time, year after year, to the tenth of a second.

How, then, can we save our theory, by which we set so much, and rightly, because it has helped us so effectively in studying Nature? If we may be allowed such an extravagant solecism, let us suppose that the engineer of our previous illustration was the hero of a fairy-tale. He has built a mill, set a steam-engine in the basement, arranged his spindles above, and is connecting the pulleys by the usual belts, when some stern necessity requires him to transmit all the energy with cobwebs. Of course, a good fairy comes to his aid, and what does she do? Simply makes the cobwebs indefinitely strong. So the physicists, not to be outdone by any fairies, make their ether indefinitely elastic, and their theory lands them just here, with a medium filling all space, thousands of times more elastic than steel, and thousands on thousands of times less dense than hydrogen gas. There must be a fallacy somewhere, *and I strongly suspect it is to be found in our ordinary materialistic notions of causation*, which involve the old metaphysical dogma, "*nulla actio in distans*," *and which in our day have culminated in the famous apothegm of the German materialist*, "*Kein Phosphor, kein Gedanke.*"

If my reviewer will compare this passage with what I have said on the undulatory theory, he will, perhaps, discover that my observations are at least proof against the charge of frivolity and irrelevancy. And it is not necessary to add, I hope, that it is no more my intention than that of Professor Cooke to call upon the physicist to throw away the undulatory theory as a working hypothesis before he has a better one.

I now come to Professor Newcomb's reflections on my discussion of transcendental geometry. Here are some of them:

In considering the author's work in detail, we begin with the subject of transcendental geometry, or hyper-geometry, as it is sometimes called. We do this because his criticisms are so readily disposed of. He speaks of the "new geometrical faith"; of the "dispute" between the "disciples" of the transcendental or pangeometrical school and the "adherents" of the old geometrical faith; of the "champions" of the old geometrical creed; of the "doctrine" of hyper-space. To the refutation of these supposed erroneous doctrines he devotes no less than sixty-two pages. Now, all his criticism is founded on an utter misapprehension of the scope and meaning of what he is criticising. We make bold to say that no mathematician has ever pretended to have the slightest evidence that space has four dimensions, or was in any way different from what is taught in our familiar system of geometry. He has not been an adherent or champion, or held any doctrine on the subject. Now and then it is barely possible that a physicist might be found—Zöllner, for instance—suggesting such a thing in a moment of aberration. But the great mass of men in their senses remain unaffected by any such idea.

Again:

Whatever we may say of the utility of such investigations, one thing is certain—they are perfectly harmless. At the very worst they can do no more injury to scientific conceptions than the careless author of an elementary algebra will do his pupil by loading an hypothetical baker's wagon with more loaves of bread than the baker could get into it. If Judge Stallo had taken up a book on algebra, found a problem the answer to which required five thousand loaves of bread to be carried by a single baker, and had devoted sixty-two pages to an elaborate statistical and mechanical proof that no wagon could possibly hold that number of loaves, his criticisms would have been as valuable and pertinent as those which he devotes to his imaginary school of pangeometry.

After reading these passages I am sorely perplexed. When Professor Newcomb penned them he had before him my extracts (in a note to page 211 of my book) from the Exeter address of Professor Sylvester, embodying a reference to the speculations of Professor Clifford, and another independent citation from Clifford's writings on page 213. And, being himself a writer on geometry of more than three dimensions, he can hardly have been ignorant of the many other pangeometrical speculations respecting the necessity of assuming the existence of a fourth dimension for the purpose of explaining certain optic and magnetic phenomena. There are mathematicians and physicists in Europe—excellent mathematicians and physicists, too—who maintain that space must have at least four dimensions, because without it a reconciliation of Avogadro's law with the first proposition of the atomo-mechanical theory is impossible. According to them, experience shows that matter has not only *extension* but also *intension*, which directly evidences the actual existence of a fourth dimension in space. Among those who advocate views like this is Professor Ernst Mach, in Prague. How, in the face of all this, Professor Newcomb could have the hardihood to assure his readers that no mathematician has ever pretended that space has more than three dimensions, I am at a loss to understand.

But it is not worth while to quarrel with him on this head; *for his statement, that I devote sixty-two pages to the attempt at proving that space has in fact but three dimensions, is a pitiful misrepresentation, akin to the statement that I am the defender of the propositions of the atomo-mechanical theory.* In my two chapters on transcendental geometry there is not a page, not even a line, devoted to such an undertaking. I discuss two main questions: first, whether or not it is true, as Lobatschewsky, Riemann, and Helmholtz assert, that space is a real thing, an object of direct sensation whose "properties," such as the number of its dimensions and the form or degree of its inherent curvature, are to be ascertained by observation and experiment—by telescopic observation, for instance; and, secondly, whether or not the empirical possibility and character of several kinds of space can be deduced *a priori* from the concept of an n-fold extended multiple,

or from the abstract concept "quantity," using this term as comprehending both algebraic "quantities" and geometrical magnitudes. As subsidiary to these questions I also discuss certain minor questions, such as that of the representability of non-homaloidal forms of space; but upon the proof that there is actually no such thing as non-homaloidal or four-dimensional space I do not waste a syllable. In other words (which Professor Newcomb may find more intelligible, perhaps): my first inquiry is, not whether any one has ever discovered a fourth dimension or an inherent spatial crook by looking through a telescope, but whether there would be any use or sense in trying to make such a discovery by looking through a telescope, even if we could get a base-line large enough to meet the requirements of Professor Helmholtz; and my second inquiry is, whether or not there is any world-producing potency in an algebraic formula or an "abstract noun."

Professor Newcomb claims that investigations respecting geometry of more than three dimensions are at least harmless, and even useful, inasmuch as "they have thrown a flood of light on the origin and meaning of geometrical axioms." My answer to this is, that speculations of this sort are harmless only so long as it is not pretended that they can teach us anything respecting either empirical reality or empirical possibility. And they can throw light on the origin and meaning of geometrical axioms only by giving us an insight into the nature of the forms or modes in which the world of objective reality is or may be reproduced in the intellect. But what shall we say, then, about the grin at speculation in science which stares at us from the very title of Professor Newcomb's article? If he may throw a flood of light on the foundations of geometry, by speculating about space of four dimensions, am I to be jeered at when I endeavor to direct a feeble ray from the general theory of cognition on the same subject—when I try to do methodically what he is doing at random, and without the least suspicion that anything more is necessary for the accomplishment of his purpose than skill in the handling of an analytical formula? It may be that my undertaking has not been very successful; but *in magnis voluisse sat est.* And this leads me to say a few words in answer to the intimation of Professor Newcomb and the direct charge of my reviewer in "The Critic," that inquiries into the forms and laws of thought are sheer impertinence, and of no consequence to the physicist.

In the introductory part of his article Professor Newcomb flings at me the case of De Morgan's paradoxer Smith, who fancied that he could prove the ratio of the circumference of a circle to its diameter to be exactly $3\frac{1}{8}$, by getting somebody to admit that the ratio of the circumference to the diameter is the same for all circles, and then telling him to draw *one* circle with the diameter 1 and circumference $3\frac{1}{8}$. Now, the intellectual plight of this paradoxer, who, besides assuming the very thing to be proved, failed to see that his argument would

serve equally well to establish any other ratio, and who never thought of asking himself the question whether or not a diameter 1 and a circumference $3\frac{1}{8}$ were compatible—whether or not his postulates were consistent with each other—is closely analogous to the mental predicament of certain scientific specialists who are constantly multiplying forces, superable and insuperable, and all manner of entities, with impossible or contradictory properties, for the purpose of explaining natural phenomena. When this is done with a proper insight into the nature and use of such fictions—with the understanding that they are mere devices for fixing ideas or colligating facts (to use Whewell's expression)—it is well enough. But, in many cases, the specialists have no such insight. They begin to treat the fictions here spoken of as undoubted realities, whose existence no one can question without subjecting himself to a Newcombian fustigation. Take the case of the ether, the hypothetical substratum of luminar undulations. It is first mentioned simply as a fluid of the greatest tenuity, as wholly inappreciable to the senses, and as offering no resistance to atoms or celestial spheres. Thereupon, to meet the exigencies of the undulatory theory, it is endowed with a co-efficient of elasticity thousands of times greater than that of steel. Next, at the demand of some physicist or chemist, who wants to incase his atoms or molecules in ethereal atmospheres or envelopes, it is made as soft and mobile as hydrogen gas. First, it is looked upon as continuous; then, to explain the dispersion of light, it is made discontinuous, and "finite intervals" are interposed between its atoms. But now comes Clerk Maxwell, and shows that, if the constitution of the ether were atomic, consequences would ensue upsetting the whole theory of heat; or Helmholtz and Sir William Thomson, in order to be able to construct their vortex-atoms, require it to be absolutely frictionless and incompressible, and therefore continuous; and, accordingly, it is restored again to its ancient continuity, no matter what may become of Cauchy's theory of chromatic dispersion or Fresnel's theory of polarization. Originally there is but one ether; but presently Professor Norton contends that the luminiferous ether is not available for the purpose of explaining the phenomena of electricity and magnetism. He demands a second ether, filling the same space with the first; and his demand is complied with. In a short time Mr. Hudson appears with the claim that even the phenomena of light can not be accounted for on the supposition of a single light-bearing ether; and he must have *two* luminiferous media, "each possessed of equal and enormous self-repulsion or elasticity, and both existing in equal quantities throughout space, whose vibrations take place in perpendicular planes; the two media being mutually indifferent, neither attracting nor repelling"—and, again, his request is granted without further ceremony. To cap the climax, finally arrives the pangeometer, and insists that back of and behind all these ethers there is an independently real thing, an object of direct sensation,

space, which is probably flat, but which possibly may turn out to be inherently crooked. And now, when somebody shakes his head and proposes to examine whether there is not something wrong with this whole mode of philosophizing, which mistakes crutches for limbs, and scaffolds for buildings, Professor Newcomb hurls a wooden thunderbolt at him, or a reviewer in the New York "Critic" reminds him that "the sound thinker gives himself little uneasiness respecting the laws of thought."

Now let us look for a moment at the atom. The physicist or chemist gets it originally as an ancient heir-loom, handed down from the times of Democritus or Lucretius. It is a solid body, with attachments of hooks and loops. The modern scientist takes off the attachments, and holds on to the main solid body, polishing it for his use. So this body becomes round; but in course of time appear the mineralogist and chemist with their morphological laws, such as the law of Mitscherlich, with theories of polarity or valency, or what not; and to accommodate them it is proclaimed that the atom is a cube or a rhomb or an octahedron, or whatever else will silence the most clamor. After a while, Kroenig or Clausius declares that, in the interest of his kinetic theory of gases, he must insist on the perfect sphericity of the atoms or ultimate molecules; and thenceforward (for a month at least) they are spherical. But, at the expiration of the month, Maxwell points to certain anomalous facts which are supposed to be inconsistent with atomic sphericity, and he suggests that it be modified so as to give the atoms the form of oblate or prolate spheroids; and, of course, his suggestion is adopted. In a short time some physicist rushes out of his laboratory or study, and announces that he has just obtained experimental results or arrived at theoretical conclusions requiring an utter rejection, not only of the definite figure of the atom, but of its entire bulk; and forthwith it is subtilized into a mere center of force. But now the physicist is reminded that force must have a substratum, and that its indispensable correlate is inertia. At this juncture the pangeometer flits upon the scene, and offers the perplexed physicist his fourth dimension in which to lodge both the extension and "intension"—i. e., mass—of the centers of force, assuring him that he may have the mere punctuality of the atom in ordinary space, and behind it, in space of four dimensions, any amount of bulk and weight. At this stage of the proceedings the physicist begins to look desperate; perhaps he is silently meditating the question, What is to become of experimental research if the properties of things can vanish *ad libitum*, and retire into the recesses of the pangeometrical regions? And yet, woe to him who ventures to suggest to the chemist that the origin of the trouble is not in his retorts, but in the sincipital alembic through which all his results are at last distilled, or to show the physicist that there is no defect in the lenses of his microscope, but great want of achromatism in those of his intellect! He speedily learns that the

stupid arrogance of dogmatism, which it is the special function of science to repress, has some of its most vulgar representatives in the ranks of those who claim to be, not only votaries of science, but its chosen protagonists and defenders.

Some years ago Fechner, in the first edition of his "Atomenlehre," printed an answer he had made to some one who objected to the theories of the physicists about atoms, ethers, forces, and so on. It was something like this : "I have a handful of coins. You are not pleased with the effigy and inscription, and advise me to throw them away; yet you offer me nothing to replace them but an empty purse." If that speech had been made to me, I should have met it with this reply: "The mischief is that your coins are spurious ; they are base metal. Nevertheless, they may serve a good purpose as mere counters or tokens, provided you never lose sight of the fact that they are nothing more. But experience teaches that you *do* constantly lose sight of that fact, and in a short time insist dogmatically that the coins are of unquestionable intrinsic value. And, having found out that you can manufacture any amount of them at little expense, you do what all inflationists and debasers of the currency are in the habit of doing : you flood the market with stuff which must inevitably bring ruin upon the very man whom you have ensnared into the belief that he can never have enough of it, viz., the laborer who is employed in the hard work of producing the material out of which science is to be constructed. So, if you are unable to procure genuine theoretical specie to represent the scientific wealth you are intent on accumulating, and at the same time are unwilling to restrain your propensities for manufacturing spurious coin and palming it off on yourself and others as sterling cash, you had better carry your facts about in baskets or bags, and resort to the ancient clumsy method of barter."

I will not weary the reader by drawing upon the rich store-house of theoretical chemistry for further illustration of the manner in which provisional and tentative hypotheses are paraded as absolute finalities, and results of experimental research are obscured instead of being irradiated by theoretical conceits. I will content myself with a single further reference to a very recent and very remarkable exemplification of the proneness of the very ablest men of science to multiply entities and confound modes of physical interaction or forms of intellectual apprehension with indestructible things.

In the scientific journal, "Nature," for May 26, 1881 (vol. xxiv, p. 78), there is a communication from Professor Silvanus P. Thompson, containing an extract from the preface to his then forthcoming book "Elementary Lessons in Electricity and Magnetism," in which he says :

> The theory of electricity adopted throughout is, that electricity, whatever its nature, is one, not two ; that electricity, whatever it may prove to be, is not matter and is not energy ; that it resembles both matter and energy in one respect, however, in that it can neither be created nor destroyed.

Accordingly, Professor Thompson supplements the doctrines of the "Conservation of Matter" and "Conservation of Energy" with the new doctrine of the "Conservation of Electricity," which, indeed, is the title prefixed to his communication.

There are, of course, thoughtful physicists (and their number is increasing from day to day) who do not share the delusion that every momentary device for sorting and grouping facts is to be hailed as a new scientific revelation, and who do not dream of calling upon any one to uncover his head before every passing conceit as though it were an eternal truth. But, unfortunately, these men are not always in the high places, and are averse to obtruding themselves in public as vindicators of the authority of science.

I certainly cherish sentiments of the sincerest admiration and respect for the high-minded and generally modest men who devote their energies to the extension of the bounds of knowledge, and, in the interest of thorough and effective work, shut themselves up in narrow and dingy workshops from whose windows a wide survey of the scientific horizon is difficult or impossible. And I appreciate fully the impropriety of troubling and interrupting them with idle and frivolous criticisms and suggestions. I know that they are under the necessity of arranging and combining their crude materials upon such principles and hypotheses as they have at hand—that they can not make bricks without straw. But when a scientific specialist appears as an intruder in discussions for participation in which his habitual occupations have tended, not to qualify, but to disqualify him; and when, instead of listening and saying what he has to say respectfully, he turns to the crowd and vociferates about "charlatans," "pretenders," and "paradoxers," my thoughts involuntarily run into the words of an old Greek which have been stored in my memory since my boyhood days:

Ος δέ κε μητ' αὐτὸς νοέῃ μήτ' ἄλλου ἀκούων
'Εν θυρμῷ βάλληται, ὅδ' αὐτ' ἀχρήϊος ἀνήρ.

THE EYE-LIKE ORGANS OF FISHES.

By Dr. ERNST KRAUSE.

ONLY a few biological studies can count on so general an interest as those which concern the diversities in the sense-life of animals. We wonder at the stories of snails and mussels that have ears in their feet, or on their backs, or in the folds of their mantles, or which, like the Argus of mythology, have many eyes, or which have eyes on all their limbs; or of those creatures which, like some fishes, have organs of taste all over their skin; or of animals on which have been discovered nervous organs that do not seem to relate to any of

our recognized sensorial functions, but rather point to some sixth sense, unknown to us. To this class belong the phenomena presented by a group of bony fishes, living for the most part at extreme sea-depths, classified in the three related families of the *Scopelids, Sternoptychids,* and *Stomiatids,* which have lately received attention from naturalists. They are generally small fishes, often only an inch or less in length, and have on either side of their belly a row of bright spots, extending from the snout to the tail, that might be said to look like a double row of pearl-buttons fastened upon their skin-coat. Sometimes a third row is found extending from the head to the anal fin ; and frequently single spots, often of considerable size, are scattered over the head and gills and over the sides of the fish. Several ichthyologists—among them B. Rafinesque, of Palermo ; Delle Chiaje, of Naples ; Risso, of Nizza ; and Cocco, of Messina—have had their attention drawn, since the first decade of the century, to specimens of those creatures that have occasionally been washed ashore in storms ; and the more recent deep-sea investigations have made several allied forms known. The old ichthyologists apparently never examined the spots very carefully, but simply described them as silvery mottles or light points. Leuckart seems to have given them the first critical examination in 1864, in *Chauliodus Sloani, Stomias boa,* and *Scopelus Humboldtii,* and came to the opinion from it that they might possibly be regarded as supplementary eyes. Ussow, of Moscow, published a paper in 1879 on the structure of the so-called eye-like spots in *Chauliodus, Stomias, Astronesthes, Gonostoma,* and *Maurolicus,* in which he expressed the conclusion that the spots in the

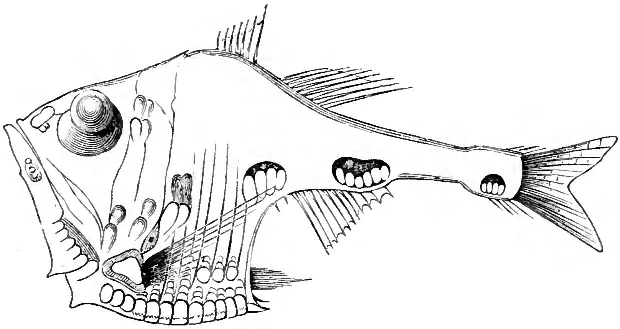


FIG. 1.—*Argyropelecus hemigymnus*, twice the natural size.

three first-named genera were real organs of sight, but that the structure of those in the other genera was of a quite different nature, and really glandular. In the same year Leydig published a work on the *Chauliodus Sloani,* in which he admitted the similarity of the spots of that species to eyes, but was disposed to regard them as transitional organs rather than as real eyes, and referred to one of his observations as indicating that they might have been luminous in life. Leydig has more recently examined ten other species of the families *Sternopty-*

chidæ and *Scopelidæ* (from specimens preserved in spirit), and has considerably advanced the solution of the question of the office of these organs.

The organs in the *Sternoptychids* and the *Scopelids* show essential differences in structure, and a third type has been noticed in some scopelids. Hence, Leydig has described three classes of organs, consisting—1. Of eye-like organs; 2. Of organs of a glass-pearly appearance; and, 3. Of luminous organs. These three forms can be easily distinguished with a glass. The organs of the first class resemble brownish sacks filled with a gray matter; those of the second class brown-bordered, plate-shaped depressions, the ground and edges of which are covered by a film with a metallic luster; and those of the third class, confined to the genus *Scopelus*, present themselves as larger spots of a silvery luster, or a grayish pearl-color.

The eye-like organs—which we have already spoken of as arranged in rows along both sides of the lower central line of the body—are also found on the head about the nose and eyes, on the lids and skin of the gills, and, in the genus *Chauliodus*, in groups of much smaller spots within the cavities of the mouth and gills. The number of the spots, which hardly ever exceeds a hundred in the other genera, rises in this genus to a thousand and more. Their outward appearance is not quite the same in the different parts of the body, but passes from the form of a round sack to that of a cylinder; and some spots are of the shape of a bell or an ampulla. In the genus *Argyropelecus* (Fig. 1) the organs are grouped. They consist of an integument of brown

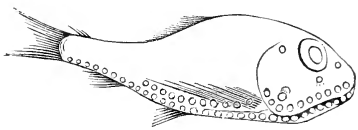


FIG. 2.—*Ichthyococcus ornatus*, twice the natural size.

pigment, which is coagulated from the thick skin and forms a ring-fold, or gather, dividing the interior into a forward and hinder part. Within this integument is a film of a bright metallic luster, which either underlies the whole of it, or only forms a belt at the mouth, and consists of iridescent threads or spangles lying in the thick skin. The gray inner mass is divided into two sections, a larger hinder part filling the sack, and a smaller forward part. The hinder part is always spherical, the forward part cylindrical, and the two together form a connected whole. To both parts appertains a radial striation proceeding from a frame-work that is continued within from a membrane inclosing the gray mass. The longitudinal section of the hinder part of the organ superficially resembles the cross-section of an orange. We have to deal here, however, not with a few pervading radiations, but with a hollow cone of radiations meeting in the center, a certain

number of which stream out over the spherical circumference of the sack, and fill the neck-part debouching without, so as to give the figure of a cone of rays sunk into the sphere. The net-work is, like that of the orange, filled with small cells, a part of them strongly refracting the light, which pass toward the common point of radiation of both divisions into an opaque granular substance. A nerve is always present in the neck-region of this organ, the fibers of which appear to be lost in the granular midst of the spherical section whose exact histological relations have not been ascertained. Externally, the whole organ is inclosed in a lymph-chamber.

The glass-pearly organs are also distributed over the sides of the belly, the head, the gill-flaps, and the skin of the gills, and the three on the skin of the gills are always longer than the others. They are of the shape of a round disk a little sunken, with a body having a metallic

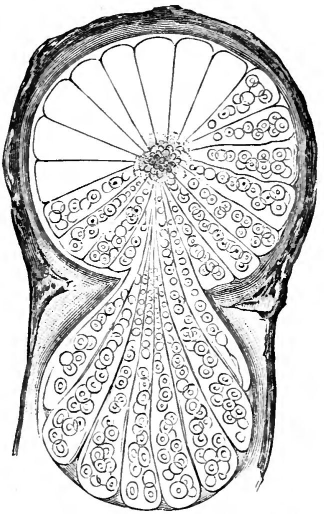


FIG. 3—EYE-LIKE ORGANS FROM THE BORDER OF THE BELLY OF *Argyropelecus hemigymnus;* longitudinal section, greatly magnified.

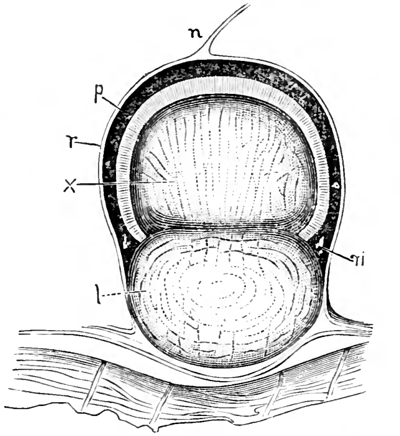


FIG. 4.—LONGITUDINAL SECTION OF THE EYE OF *Stomias anguilliformis* (after Dessow), with the parts designated thus: interior vitreous substance (*x*); lens (*l*); retina (*r*); pigment layer (*p*); iris-like fold (*ir*), and optic nerve (*n*), greatly magnified.

luster and overlaid with a curved transparent integument. An outer brown film of pigment is always present, with a layer of closely joined, regular, hexagonal plates, and a latticed jelly-tissue of delicate, radiated cells that form a net-work, and are lifted up under a roof-like, spiral-shaped concretion (Fig. 5). The nerve-bundles are also present. Quite similar, but distinguished chiefly by their larger size, is the structure of the so-called luminous organs which are present in the *Scopelus Rafinesquii* and *Scopelus metopoclampus* as brightly glittering, well-defined spots above the nasal openings and under the eyes, and which in *Scopelus Humboldtii* and *Scopelus Benoitii* exhibit the form and appearance of depressed pearl-spots.

Concerning the nature of these organs, Leydig denies that any of them are glandular, although Ussow admits that this may be the case with some of the fishes. The hypothesis that they are organs of a sixth sense has received no confirmation. There remains, then, the theory proposed by Leuckart, Ussow, and Leydig, and accepted by Semper as undoubtedly correct, that they are real subsidiary eyes, like the eyes of mussels, etc. Leuckart and Ussow believed that they were able to distinguish a lens, a vitreous substance, and a retina, and the latter has published drawings of those parts; but the careful examinations of the structure of the organs and comparisons between it and the eyes of mollusks have led Professor Leydig to doubt this opinion; for he has observed that, when the fish swims horizontally, the mouths of the supposed eyes are turned, not toward the light, but downward, toward the dark bottom. Still less do the glass-pearly organs resemble eyes. Leydig is rather disposed to believe that he can with great probability recognize an identity in their structure with that of the electric and pseudo-electric organs of some fishes, particularly in the jelly-tissues and the disposition of the nerve-endings. According to this view, each of the disks would in itself correspond to a chest of the electric organs. The round shape of the disks may be explained by their isolated situation, there being no pressure of one upon another to make them angular. A similar diversity prevails in the form of the electric and pseudo-electric organs to that existing in the organs which we are considering, while the homology of the two is strikingly expressed in their similar situation and distribution. Leydig believes that two series of formations of this kind have been devel-

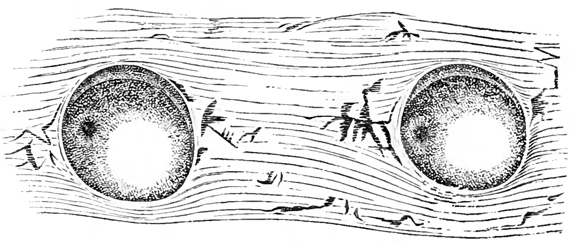


FIG. 5.—TWO "GLASS-PEARLY" ORGANS FROM THE SIDE OF *Scopelus Humboldtii*, moderately magnified.

oped, one of which leads through the pseudo-electric organ of the *Gymnarchus niloticus* and the disk-like organs of the Scopelids to the real electric organs, while the other series includes the eye-like organs of the sternoptychids; an apparatus which is also represented in the larvæ of salamanders.

The appearance of this phenomenon in the amphibia, frequently observed as they approach the fish type, should point to some definite connection between the activity of those organs and water-life; but the nature of this activity, whether electricity is developed by it or not, is still veiled in complete darkness.

These organs have been regarded by many as luminous organs. A single glance shows that the body and lateral walls of the disk shine with a silvery and golden luster, but not different from that of the background of a fish's eye when viewed before a screen. More striking is the appearance in the case of the larger organs of the head in certain species, which are pre-eminently marked by it as a luminous apparatus. But, if the sole object of the apparatus were the collection and reflection of the light which fell upon the fish, its complicated structure in other respects, and its innervation, would be superfluous and still more incapable of explanation. We have, however, an observation that seems to show that these organs not only collect light, but are also really phosphorescent. The distinguished naturalist of the Challenger Expedition, Willemoes-Suhm, now deceased, saw Scopelius phosphorescent in the night, of which he says: "One of them hung in the net like a shining star as it came out of the darkness. Possibly the seat of the light is in the peculiar side organs, and it may be that this phosphorescence is the only source of light in the great depths of the sea." The thought that in the dark abysses of the deep sea every animal carries its lantern as the miner carries his lamp on his head, is a very fascinating one; and, indeed, Herr Willemoes-Suhm observed several other fishes that were provided on the smooth head and on the head-beard with "a remarkably large sense-organ." Valenciennes has also remarked of the genus *Hemiramphus* that it bears a strongly glittering phosphorescent pustule on the tip of its tail. Although the majority of these animals have never been observed in a living condition, we might easily agree to the opinion that the or-

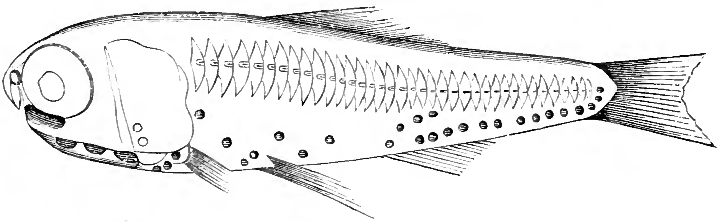


FIG. 6.—*Scopelus Rafinesquii*, twice the natural size. Two luminous organs in the ocular region.

gans of all three categories serve as a more or less perfect illuminating apparatus; and, if we compare Professor Leydig's sections of them, this opinion, which is only very apparent at the first view, becomes extremely probable. Especially does the section of the eye-like organ of *Argyropelecus* and *Ichthyococcus* resemble the illuminating parts of a projection-apparatus. If we conceive the granular spot in the center, into which the nerves enter, as the source of light standing in the middle of the apparatus, there are likewise behind this the concave reflector, and in front of it the diaphragm through which the concentrated cone of rays is thrown outward under a strong refraction.

In the pearl-like organs, also, if we have understood Professor Leydig's description aright, a curved, refracting body seems to lie on the side of the organ that is turned outward. We should thus, if our presumption is confirmed, have here not a simple illuminating organ, but a complete optical illuminating apparatus in different degrees of perfection, throwing out in an extremely concentrated condition, by means of a concave mirror and lenses, the phosphorescent light generated within it; and the fishes under consideration would be fully equipped with a series of little, button-shaped illuminating apparatuses.

I may assert here that there is nothing hazardous in this idea. As Professor Leydig has maintained, the "eye-like," and the "pearl-like," and the really luminous organs, are of thoroughly homologous structure, and we know of the latter, the only ones that have been observed in a living animal, that they emit a star-clear light. If, now, Nature has provided us with a most wonderful *camera-obscura* in our eyes,

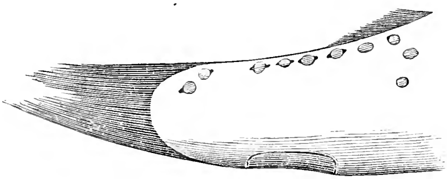


Fig. 7.—Caudal Extremity of *Scopelus Humboldtii*, with "glass-pearly" organs, and a large pearl-spot.

why may she not also have produced a much simpler light-house lantern—provided, of course, that such an apparatus could be useful to the animal? I have already had something to say concerning the uses of their luminous apparatus to different animals ("Kosmos," vol. vii, p. 479), and have endeavored to show that their principal service is probably as a means of exciting fear. At any rate, the opinion may be given up that the light diffused by the deep-sea animals is a means of clearing up the purple darkness below, or, as some have thought, of producing the diversified hues of the deep-sea animals. Animals living in the dark do not require light for their existence, as is demonstrated by the numerous blind cave-animals. The opinion, also, that the luminous fish make their prey in any way visible by means of the organs subsidiary to their eyes could not in any degree help to account for the existence of luminous apparatus on the lower part of their bodies, for their eyes would not be able to see what those organs lighten up; but such organs might very well make the animal more visible from a distance, and might thereby serve a similar purpose with the protective colors of the animals of the upper world, especially if the appearance were associated with a disagreeable taste or smell. Only in some such manner as this can we account for the luminous organs, for example, of a crustacean that was brought up by the Challenger Expedi-

tion from a depth of nineteen hundred fathoms, and which was totally blind.

Professor Leydig remarks upon this point that the luminosity is, for the most part, only a subsidiary shining dependent on the secretion of a fatty body, and that the significance of the formations as electrical and pseudo-electrical organs is not altered on that account. We might also remark on this subject that, according to Kölliker's observations, the luminosity of many animals is under the influence of the will, so that the innervation of the phosphorescent organ no longer seems superfluous; and that, according to Jousset de Bellesme, glow-worms cease to shine as soon as their principal ganglion is removed. Moreover, according to Bellesme's observations, the glow may be produced by electrical as well as by nervous excitation. At all events, the hypothesis which I have submitted appears to me to be worthy of a searching examination.—*Translated from Kosmos.*

THE APPOINTMENT OF COLLEGE OFFICERS.

By F. W. CLARKE.

THERE are to-day in the United States over four hundred institutions claiming the title of college or university. Some of them are really, a few confessedly, only high-schools or academies; and between these and the highest there is every diversity of grade. In them there are over four hundred "presidents," "principals," "chancellors," or whatever the heads of the institutions may be called, and some thousands of professors or teachers. This great body of men and women is continually changing; yearly there are deaths, removals, and resignations; yearly there are a multitude of new appointments. The purpose of this essay is to inquire how such appointments are made, and how they ought to be made; what considerations do govern, and what should govern, the selection of college officers.

At a casual glance it would seem as if little could be said upon the subject; of course appointments are made by regular boards of trustees, and of course each appointment is determined by the peculiar fitness of the successful candidate for the position he is to occupy. Such is the theory, but the application thereof may be exceedingly elastic. Strange standards of fitness are frequently adopted; and appointments to responsible positions are often made upon principles which would be recognized in no other kind of business except the trade of partisan politics. In political life an efficient officer may be displaced for mere party reasons, and supplanted by some one altogether his inferior. In the college world, slight shades of difference in theological belief are at times similarly potent.

The qualifications demanded of a college president are different in different places. In some institutions the head is purely an executive officer, with no teaching to do; in others he must fill a professor's chair also. On the one hand, a man of general scholarship, breadth of view, and executive ability is called for; on the other, special familiarity with some particular branch of learning must be added to the requirements. To find all these qualifications united in one individual is by no means easy. A man of one ability is easily found at any time; but men of many abilities, at once both versatile and thorough, are scarce. In any case, the college president, to be a successful manager, must have tact; he must have executive capacity and force; he must be business-like in his methods, he must command the confidence and respect of trustees, teachers, students, alumni, and of the community in which he lives; he must be a good judge of men; and he must have the training which only experience can give. Failing in any one of these qualifications he is liable to fail altogether, for the strength of the whole chain is but that of its weakest link. He must have public confidence, in order to attract public support; he must be in harmony with the faculty, or things will go at loose ends; if the students distrust him, discipline can not be maintained. When vacancies occur in the teaching force, he will have great influence in filling them; hence he must be familiar with scholarship in its various phases, and able to decide upon the relative merits of different candidates. Finally, he must be thoroughly acquainted with college routine, clear in his views concerning courses of study and methods of instruction, up in all matters relating to marks, examinations, discipline, and the like. He should have high ideals, and at the same time be neither a *doctrinaire* nor a dreamer.

The fact that most of the older American colleges were founded with religious ends in view has had much to do in determining the appointment of college presidents. Plainly, if the chief function of the schools is to train clergymen, they should be controlled by clergymen; and so they have been controlled almost universally. If a Baptist college needs a president, some Baptist clergyman is chosen; a Presbyterian college puts a Presbyterian minister at its head, and so on. That this state of affairs has naturally come about no one can deny, but whether it is any longer a legitimate condition is questionable. The functions of the college are broader than they were a century ago; it no longer aims chiefly to feed the ministry, but seeks rather to send cultivated men and women into all walks of life. Hence, although a minister may be an efficient college president, he should not be appointed because he is a minister, but for other reasons distinctly. Just here an example may have value. A few years ago a popular clergyman was elected president of a well-known college. Within a year his popularity was gone, and students, professors, and trustees were alike dissatisfied. The reason was simple. The new head was a

clergyman only—not an educator. As head, being a man of energy, he meddled with things which he had not learned to understand, harassed the pupils, doubtless with the best of intentions, attempted to carry out impracticable measures, and made trouble generally. Fortunately, he was a man of some tact, and able to learn wisdom by experience, so that after a while order was restored, and at last he regained popularity and confidence. But he learned his new trade at the expense of the institution, which suffered during the period of his tutelage. Would it not have been better if he had begun as a tutor, then risen to the rank of professor, and finally been promoted to the presidency after he had shown his fitness? In brief, is it not safe to say in general terms that no man because of success in one profession should at once be intrusted with the highest place in another? The loftiest positions in any line, political, educational, or what not, should be earned by faithful service and proved capacity in the lower grades. There may be exceptional cases, but they are so rare as to count for nothing in establishing the general principle. Special knowledge, training, and experience are demanded of a college president just as much as of a bank cashier, an army officer, or the captain of a ship; and rules like those which govern the latter classes of appointments should hold good in the educational profession also.

Since the duties of a professor are more easily defined than those of a college president, the rules governing his appointment ought to be correspondingly simpler. In general he is to teach a single subject or groups of allied subjects, and should therefore be chosen for special knowledge of the branches indicated. If he is to fill the chair of Latin, he must necessarily be selected because of his scholarship in Latin; if he is to teach mathematics, he must be a mathematician; and so on. Furthermore, good character and efficiency are essential. It would seem as if there could be no doubt upon these points, as if no argument about them were possible; and yet, as a matter of fact, plain as they are, they are frequently ignored. Favoritism, nepotism, and sectarianism often outweigh all other considerations even in the college world; and men of no genuine scholarship secure appointments over candidates whose real credentials are vastly higher. The son of a college president may be appointed to teach some subject in which he has never been properly trained; an unsuccessful clergyman may be provided for by assignment to a professor's chair; and such things, far from being mere abstract possibilities, do actually occur. Still other absurdities are continually being perpetrated. The writer has known of a case in which a teacher was invited to take any chair he chose in a certain Western college; and of another instance in which an applicant for a professorship offered to accept any department that might be offered to him. Professors have been known to begin their own studies in the line of their professorships after they had been elected; and some years ago the trustees of one college passed a rule

to the effect that any member of the faculty could be called upon to teach any subject, under penalty of dismissal if he refused. This ignorance puts a premium upon intellectual dishonesty. It needs no argument to show that all such cases result in inefficiency and superficiality; the colleges represented by them are shunned by competent men, they suffer in reputation, and at last they dwindle into mere local academies. Fortunately, the law of natural selection holds good among institutions as among animals, and in the long run only the fittest flourish and survive.

But all vices are not great vices, and small crimes against college morality are committed even by old and famous institutions. For example, a certain Professor of Natural History has been wittily described as "a good theologian, slightly tinctured with zoölogy"; his appointment having been secured by raising false issues of the ultra-sectarian kind. It is hardly necessary to add that the highly respectable college in which he teaches is not recognized as a shining center of zoölogical research. In the same institution a teacher of mathematics was to be appointed; and an enthusiastic friend praised the mathematical ability of a leading candidate. "No matter about his mathematics," said one of the authorities, "we want to know if he is a man of good moral character." The remark was suggestive. Of course, moral character was essential, and to be scrupulously considered, but not above other qualifications equally important. Character and competency need both to be regarded; since a man may be a model of purity, and at the same time incapable of teaching even the alphabet. Candidates for professorships are often sharply catechised. "What church do you go to?" "What are your views upon such and such doctrines?" These questions are almost invariably asked. "Are you a professor of religion?" said a college trustee to a young candidate for a position. "No, sir, I am a professor of chemistry," was the reply, and rejection followed. Curiously enough, the college represented by this instance was not a sectarian school, but a State institution, founded upon the congressional land-grant of 1862. From such-like impertinent questions some of the ablest scholars in America have suffered. Pure character, unblemished reputation, high scholarship, and great achievements, are not sufficient for answers. Only a rigid conformity to certain dogmas can render the candidate's calling and election sure. Hypocrisy may succeed where real merit would avail but little.

Since a tutorship is the natural stepping-stone to a professorship, tutors should be chosen for qualifications essentially the same as those which are demanded of professors. There are now available a multitude of competent young men, who are ambitious to win professorships, and who, with that aim in view, have devoted years of laborious study to special preparation for special teaching. Some are chemists, who have pursued original investigations at Berlin, Leipsic, Bonn,

Harvard, or Baltimore; others have studied philology, under the foremost German masters; still others have become thorough biologists, students of history and philosophy, or mathematicians. From among these the ranks of tutors should be filled, and legitimate promotion, in due time, ought to follow.

At some colleges, Harvard for example, the policy above indicated is followed. If a tutor in Greek is needed, some young man who has distinguished himself in Greek is chosen; and, upon the hypothesis that he intends to make a life-work of classical study, he is given every advantage to distinguish himself still further. In some other institutions, however, a different plan is adopted. At Yale, for instance, tutors are often, if not always, appointed in a sort of general way, without particular reference to special studies, the subject to be taught by each being settled afterward. In consequence, a Yale tutor, whose real specialty is mathematics, may be obliged to teach only Latin; while another, whose bias is purely classical, may have to struggle with pupils in trigonometry. Doubtless these evils are greater in appearance than in reality; probably in most cases matters adjust themselves in a more rational way; still, in some instances, the mischief is really done. Such a state of affairs ought not to be even possible. It is sometimes urged, in extenuation, that every young man who has graduated creditably ought to be able to teach others whatever he has himself learned; and, in a measure, this is true. But a fellow may have studied mathematics only as a matter of routine, getting none of its real spirit, and putting no enthusiasm nor vigor into his work. Doubtless he can carry others through the same routine afterward, hearing recitations from a text-book, and recognizing such mistakes as may be made; but "teaching" of this kind is hardly worthy of the name. Every college teacher, whether professor or tutor, ought to *feel* the subject which he teaches; he should be able to rouse the interest of his pupils, to stimulate thought among them, to encourage the bright ones forward, and to remove difficulties from the paths of those who lag behind. Such work can be done only by special scholars, who have taken up their life-tasks as a labor of love, and who are brimful of earnestness and enthusiasm. With the lower college classes this scholarly vigor is especially needed. The pupils must be started aright at the very beginning, for, if their interest is not awakened then, there is great danger that it may continue sleeping always. But in no part of a college course should mere perfunctory instruction be tolerated. A man may be a teaching machine, and yet fall very far short of being a teacher.

Now, having discussed the reasons governing college appointments, we may fitly consider the methods by which the appointments should be made. Suppose that there are several competent candidates for a given position; how shall one be selected, and by whom? Technically, there can be but one answer to this question, namely, that the

trustees of the college must choose; but practically this answer does not fairly cover the case. The average board of trustees consists not of special scholars, but of men in active life—merchants, manufacturers, lawyers, doctors, and the like; with oftentimes a liberal sprinkling of clergymen thrown in. It may be that not one of them has any special knowledge of the branch to be taught by the proposed appointee, or any adequate means of judging independently as to the relative fitness of the candidates. In some instances, too, they meet but once a year, namely, at commencement time; and in such cases a decision must be reached in advance of the meeting. Clearly, then, they must act upon recommendations; and the practical question is, Whose recommendations shall carry the most weight?

To this question a great variety of answers are possible; as may be shown by citing three common modes of procedure: First, an election may be carried by personal lobbying; the candidates and their friends seeking out individual trustees, and, by all sorts of arguments, relevant and irrelevant, securing pledges of support. This process is objectionable enough in politics, but it is tenfold worse in educational affairs. Secondly, the president of the college may decide between the candidates, and make a recommendation upon his own responsibility—a method which is perhaps the one most generally followed. Thirdly, the faculty as such may be officially consulted, and their nominee given the appointment. Ignoring the first plan as unworthy of consideration, let us examine carefully the other two.

The efficiency of the second mode of appointment naturally depends upon the character, tact, and temperament of the college president who attempts to carry it out; and it may lead either to good results or to mischief. A wise president, having an appointment to recommend, will scrupulously consider all the interested parties. Having ascertained all the essential facts concerning the available candidates, and being satisfied as to their antecedents and ability, he will consult with his associates upon the faculty, especially with those most interested in the appointment to be made, and in his final decision he will give due weight to their advice and wishes. Theoretically, this method is simple enough, but in its practical application it is often attended by serious difficulties. Sometimes a faculty is split into cliques, and then the president must either make an independent decision, or else take sides with one faction as against another. Such dilemmas are common, and bring great uneasiness to their victims. A new president may find an old faculty half buried in a rut from which it can be lifted only by fresh and vigorous men; he may be embarrassed by alumni, who expect appointments in preference to outsiders; there may be tutors who will growl and grumble if not promoted in accordance with their own notions as to their deserts. Whichever way he turns he is liable to create dissatisfaction and heart-burning; the unsuccessful candidates and their friends all abuse him for favoritism

and incompetency ; in short, all the worst features of personality may be introduced into a contest which above all others ought to be unaffected by personal considerations. Many a college war has sprung from conflicts over appointments ; and only an exceptionally strong president can long hold out against the difficulties which such contests are apt to raise against him. With but few men is the method of personal appointments successful ; with many it leads to inharmony and overthrow.

The third method of appointment, namely, upon recommendation from the faculty, seems to be the most satisfactory of all. Of course, it is not absolutely perfect, for it may give rise to dissensions ; but, on the whole, it leads to better results than any other. The unsuccessful aspirants for position can not blame and harass one individual, as when the power of appointment is practically vested in the president alone, for the annoying responsibility is divided among several persons ; neither can favoritism be urged as the reason for any particular choice. Furthermore, since any good faculty consists of a number of men actively engaged in scholarly work, its judgment as a body concerning the fitness of candidates is more likely to be accurate than the opinion either of a president or of a board of trustees who can not be expected to give more than superficial attention to the matter. The members of a faculty know of their own knowledge what standing a candidate has as an educator, what work he has done, and what he is probably capable of doing ; and this knowledge, which frequently involves long personal acquaintance with the aspirant, is worth much more than any information derived from mere formal letters of recommendation or from hearsay. Whoever is recommended by them will be a safe person to appoint, and will be likely to work in harmony with his colleagues. They, on the one hand, calling a man to a vacant chair, will be gratified by his acceptance ; while he, on the other side, will feel grateful to them for their consideration. It is well known that this method of appointment is in vogue at the Sheffield Scientific School ; and it is said that no professor has been called to that institution except upon the *unanimous* recommendation of the faculty. The natural result is a harmonious and efficient body of teachers, and an exceptionally strong school.

Inasmuch as this third method of appointment presupposes a faculty already in existence, it can not of course apply to those schools which are in process of organization. In such cases it is best for the trustees to select a strong and competent man for president in whom they can have full confidence, and give him almost autocratic powers. Let him choose the first faculty, drawing about him such teachers as will work in unison with him and with each other ; and then refer all subsequent appointments to that body. Of course, in no case should a board of trustees surrender its own authority, but the recommendations of a faculty should be ignored only for the most substantial of reasons. Be-

tween faculty and trustees there ought to be perfect concert of action; when either body distrusts the other, mischief is sure to happen. The method by which teachers are appointed should be a matter of usage and policy, not of prescribed rule; and the method above laid down seems to be the safest in the long run. A faculty can not maintain the highest efficiency unless it is thoroughly harmonious; any jar or friction in it leads to dissatisfactions which quickly spread to the students, and the result is disastrous to all the parties concerned.

SIR CHARLES BELL AND PHYSIOLOGICAL EXPERIMENTATION.

By Dr. WILLIAM B. CARPENTER.

It has been repeatedly urged, by the opponents of physiological experimentation, that Sir Charles Bell in his later life declared that his physiological discoveries had been really made by anatomy only, and that he had only made experiments for the satisfaction of others; and a quotation to this effect has been lately brought prominently forward by Mrs. Dr. A. Kingsford, in order to set in the most unfavorable light what she characterizes as the needless, fruitless, and barbarous experiments of Magendie on the same subject.

As it is probable that the vivisection question will be again brought before Parliament, I think it important that the public should be informed of the *real* history of the discoveries with which Sir Charles Bell is commonly credited; that history having been most erroneously narrated by his brother-in-law, Mr. A. Shaw* (who may be presumed to have written with Bell's sanction and authority), and its errors, though fully exposed at the time† (during Bell's life), having been repeated and even exaggerated by the most recent of his biographers.‡

The great discovery ordinarily attributed to Sir Charles Bell is that of the distinctness of the *motor* and *sensory* nerve-fibers; as shown by the separate existence of motor and sensory endowments, (1) in the anterior and posterior *roots* of the spinal nerves, in whose *trunks* these two orders of fibers are bound up together; and (2) in certain nerves of the head, some of which are motor only, while others are sensory only. These doctrines, according to Mr. A. Shaw, had been conceived as far back as 1809; and were then embodied in a tract which Bell printed for private distribution among his friends,#

* "Narrative of the Discoveries of Sir Charles Bell in the Nervous System" (1839).

† "British and Foreign Medical Review," January, 1840.

‡ "Encyclopædia Britannica," vol. iii (1875).

\# Sir Charles Bell himself fixed the date as 1811.

under the title "Idea of a New Anatomy of the Brain." In support of this statement Mr. Shaw cited certain passages from Bell's very scarce tract, which, read in the light of subsequent events, seemed an adequate justification of it. But, unluckily for the credit of both, a copy of the tract had found its way into the possession of a certain Mr. Alexander Walker, who had claims of his own to advance; and he reprinted it in full in a thin volume (now before me) published anonymously in 1839, under the title of "Documents and Dates of Modern Discoveries in the Nervous System."

I well remember the sensation which was produced at the time, among those who took an interest in the subject, by this publication; from which it plainly appeared that the fundamental conception enunciated in this "Idea" had gone no further than this—"that the nerves of sense, the nerves of motion, and the vital nerves, are distinct throughout their whole course, though they seem sometimes united in one bundle; and that they depend for their attributes on the organs of the brain to which they are severally attached"; while, in carrying out this conception, Bell, misled by his anatomy, had *gone altogether wrong.*

This doctrine was by no means new. It had been known from a very early period that our limbs can only feel or move (I use these words in their *ordinary* sense) by virtue of the nerve-trunks which connect their skin and muscles with the spinal cord, and through it with the brain. And although, when a limb is paralyzed, it is usually deprived at the same time of feeling and of motion, yet as cases were occasionally observed in which motion was lost without feeling, or (more rarely) feeling was lost without motion, the idea arose that two distinct sets of fibers may be bound up in the same trunks; one for feeling and the other for motion—or, as we should now express it more scientifically, one set conducting impressions made on the sensory surfaces toward the central *sensorium*, while the other transmits nerve-force from the *motor* centers of the nervous system to the muscles which it stimulates to contraction. This idea found distinct expression in the writings of certain ancient medical authors; and cropped up from time to time in modern medical literature, some writers approving it, while others dissented from it. And it was formally advanced in 1809 by Mr. Alexander Walker, who, in a paper entitled "New Anatomy and Physiology of the Brain in Particular, and of the Nervous System in General," published in the "Archives of Universal Science" for July in that year, argued that "medullary action" (or, as we should now say, a nerve-current) "commences in the organs of sense; passes, in a general manner, to the spinal marrow, by the *anterior* fasciculi of the spinal nerves, which are, therefore, *nerves of sensation*, and ascends through the anterior columns of the spinal marrow, to the hemispheres of the cerebrum," in which he located the *sensorium commune.* Thence he traced his "medullary action"

downward and backward into the cerebellum, which he supposed to be the center of *volition;* from this "it descends through the posterior columns of the spinal marrow, and expands through the *posterior* fasciculi of all the nerves, which are, therefore, the nerves of *volition*, toward the muscular system."

Thus, then, it is clearly Mr. Alexander Walker who must be credited with the first promulgation of the *idea* of the functional distinctness of the anterior and posterior roots of the spinal nerves, in virtue of what he supposed to be their connections with the cerebrum and the cerebellum respectively: but, working out this idea under a wrong conception of the relative functions of the two brain-centers, he was led to regard the *anterior* roots as *sensory*, and the *posterior* as *motor;* and, as he neither submitted nor proposed to submit this erroneous doctrine to the test of experiment, it fell unheeded to the ground.

Now, those who only know the history of Bell's work either directly or indirectly through Mr. A. Shaw's first account of it, will be considerably surprised to learn that (whether or not he was acquainted with Walker's speculations) he pursued, in the first instance, precisely the same anatomical track; and that, through his having followed this under the guidance of another wrong preconception as to the functions of the cerebellum (which had not at that date been elucidated by experiment), the physiological conclusion at which he arrived was even further from the truth than that of his predecessor.

A distinguished Edinburgh professor of the last century, Dr. Robert Whytt, who had studied with great care what he termed the "vital and involuntary motions" of the body, had argued with considerable ingenuity that, while the *cerebrum* is the center of sensation and the originator of voluntary motion, the *cerebellum* is the organ of such "vital and involuntary motions" as the action of the heart and the muscular walls of the alimentary canal, together with the movements of respiration. Now, Bell, brought up in the Edinburgh school, and commencing his investigations under the influence of this prepossession, was led by it in an entirely wrong direction; for the whole argument of his "Idea" is to the effect that the *anterior* roots of the spinal nerves minister *both to sensation and voluntary motion*, in virtue of their connection with the cerebrum, while the *posterior* roots "govern the operation of the viscera necessary to the continuance of life," in virtue of their connection with the cerebellum. He did institute experiments, indeed, both on the columns of the spinal cord and on the roots of the spinal nerves; but, under the influence of his anatomical preconception, he entirely missed the true meaning of their results, and deemed them to be confirmatory of his erroneous views:

"EXPERIMENT I.—I opened the spine, and pricked and injured the posterior filaments of the nerves; no motion of the muscles followed.

I then touched the anterior division; immediately the parts were convulsed."

"EXPERIMENT II.—I now destroyed the posterior part of the spinal marrow by the point of a needle; no convulsive movement followed. I injured the anterior part, and the animal was convulsed."

The experiments thus narrated by Bell in a letter to his brother, dated March 2, 1810, have been cited as proving that he had thus early attributed motor functions to the anterior roots, and sensory to the posterior. But the inference which he himself drew from them at the time was altogether different:

"It is almost superfluous to say that the part of the spinal marrow having sensibility [i. e., the anterior column] comes from the cerebrum; the *posterior and insensible part* belongs to the cerebellum."

Thus, although on the track of a great physiological discovery, Bell allowed himself to be completely diverted from it by his anatomical preconception. Of the *true* functional relations of the two sets of nerve-roots, there is *not the remotest hint* in this "Idea."

None the less, however, do I recognize in it what (to my mind) constitutes the *real* basis of Bell's claim to the elucidation of the meaning of the double origin of the spinal nerves. "Considering," he said, "that the spinal nerves have a double root, and being of opinion that the properties of the nerves are derived from their connections with the parts of the brain, I thought that I had an opportunity *of putting my opinion to the test of experiment, and of proving at the same time that nerves of different endowments were in the same cord and held together by the same sheath.*" This was, unquestionably, one of the most fertile suggestions that the insight of a man of genius has ever put forth for the guidance of physiological inquiry; and, even if Bell had never himself pursued it further, he would clearly be entitled to a very large share of any discoveries that others might make by working upon it. It seems, however, as if the unsatisfactory character of the results he obtained and his dislike to experimentation upon living animals turned his thoughts in a different direction; and he applied himself for some years to the study of the nerves of the face, on the peculiarities of whose anatomical distribution he seems to have long pondered, with the idea that these might furnish him with the key of which he was in search.

Bell, as is well known, had considerable artistic ability; and one of the earliest of his publications was his very valuable "Anatomy of Expression," in which he pointed out how close is the relation between many of the muscular movements by which the emotions are expressed and those concerned in respiration. Still, as it would seem, under the "dominant idea" of a special set of nerves for the "vital and involuntary motions," he assigned this special motor function to the *seventh* pair, which arises by a single root, and supplies the muscles of the face generally; while he supposed the *fifth* pair, which arises (like

the spinal nerves) by a double root, to be the nerve of ordinary (or voluntary) motion for the muscles of the face generally, as well as of sensation for its sensory surfaces. The analogy of the fifth pair to the spinal nerves (which was no new idea) seemed to him to be further indicated by the existence of a "ganglion" upon its larger root, corresponding with that which is seen on the posterior roots of the spinal nerves. Following up this train of reasoning, he *instituted experiments* with the view of determining what function the fifth pair *had* in virtue of its double root, which the seventh pair *had not.* And as he found that division of the seventh pair, while partially paralyzing the muscles of the face, did not in any perceptible degree impair its sensibility, while section of either of the three divisions of the fifth pair destroys the sensibility of the part of the face it supplies, he came to the conclusion that the sensory endowments of the fifth pair are due to its possession of a double root; a conclusion which he strengthened by the consideration that the third, fourth, and sixth nerves—which, being distributed exclusively to the muscles of the eyeball, can not be supposed to have any but motor endowments—all arise by single roots.

In this way, Bell was led to assign to the two roots of the *spinal* nerves the same double function which he attributed to the two roots of the fifth pair of nerves of the head; and thence to assign the sensory function to the posterior roots, because, like the second root of the fifth, they bore ganglia before uniting with the motor roots.* Now, to say that Bell, by this train of reasoning, *discovered* the motor and sensory functions of the anterior and posterior roots of the spinal nerves, is utterly preposterous. He had not even truly determined (as the event proved) the true functions of the fifth and seventh nerves of the head. And the extension of his conclusions regarding the double roots of the fifth pair, to the spinal nerves generally, had rather the character of a happy guess than of a logical sequence. No scientific physiologist at the present time would think himself justified in putting forward such an extension as more than a *suggestion*, to be confirmed or negatived by experimental evidence. And let it not be forgotten, moreover, that it was *experiment alone* which afforded Bell any reason whatever for attributing a sensory function to the gangliated root of the fifth pair; and that, without this basis, the question of the spinal nerves remained exactly in the condition in which he had taken it up.

It is, indeed, not a little curious that in the two memoirs (1821 and 1822) in which Bell presented to the Royal Society the results of

* It is a significant indication of the chaotic ignorance which prevailed on this subject "sixty years since," that, as Bell himself informs us, he found himself met, when first groping at the notion of the sensory endowments of the posterior roots of the spinal nerves, by the current doctrine that the function of the ganglia is "to cut off sensation," i. e., to allow these nerves to minister to the "vital and involuntary motions," without our being made conscious either of those movements or of the impressions which excite them.

his investigations into the fifth and seventh nerves of the head, the present doctrine of the spinal nerves is *nowhere explicitly stated.* These memoirs can scarcely, indeed, be read in any other sense ; and "A Manual of Anatomy," published by Mr. John Shaw (another brother-in-law) in 1821, contains a tolerably clear intimation of it. Moreover, Mr. J. Shaw, having visited Paris in 1821, and having repeated to Magendie the experiments on the fifth and seventh nerves which he had made with Sir C. Bell, further pointed out to him (as appears from Magendie's own narration) * the analogy of the fifth to the spinal nerves, and attributed to the double roots of these "regular" nerves this double function of motion and sensation.

It was at this point that Magendie took up the experimental inquiry, both as to the roots of the spinal nerves and the functions of the fifth and seventh nerves of the head ; and it will be convenient to dispose of the latter in the first instance. He showed that the second of the three divisions of the *fifth* pair is a nerve of sensation only ; so that the part of the face which it supplies (between the eyes and the upper lip) depends for its motor action on the *seventh* pair, which he regarded as the *ordinary motor nerve* of the face, ministering to its *voluntary* movements, as well as to those of expression and respiration. These corrections (which were confirmed by other experimenters) were not only accepted by Sir C. Bell, but were *appropriated by him as his own ;* the reprints of the two memoirs just referred to being altered in successive editions of his "Nervous System of the Human Body," by omission, addition, and variation, not only without any acknowledgment of the source of the correction, but without the least intimation of a change. It is clear, therefore, that although he shrank from making experiments himself, he was ready enough to profit by those of others.

On testing experimentally Bell's idea of the functions of the anterior and posterior roots of the spinal nerves, and varying his experiments in every way he could think of, Magendie was only able to arrive at this general conclusion—that the anterior roots are *more especially motor*, and the posterior *more especially sensory.* For he could not get over the fact that irritation of the anterior roots in the living animal called forth signs of pain, and that irritation of the posterior roots called forth movements. The repetition of the same experiments by others gave no more conclusive results ; until, in 1831, Johann Müller (afterward the celebrated Berlin professor) was able, by a very carefully devised method of experimentation upon frogs, to show that, for these animals at least, Bell's doctrine was correct. And it was by the extension of the same method to warm-blooded animals, and by the light of the new ideas then dawning † as to the "reflex

* "Journal de Physiologie," October, 1821.

† The very clear ideas long before promulgated by Prochaska on this point had been entirely forgotten.

function" of the spinal cord (which up to this time had been generally looked on as a bundle of nerves), that the truth of Bell's doctrine came at last to be fully established. For the *movements* called forth by irritation of the *posterior* roots were found to be due, not to the direct transmission of motor impulses from them to the muscles, but to the transmission of a motor nerve-current through the anterior roots, in response to the stimulation given to the spinal cord itself by the irritation of the posterior; while, on the other hand, it was made clear that the indications of *pain* given when the *anterior* roots are irritated, are due to the presence, in those roots, of sensory filaments derived from the posterior, which pass inward at the point of junction between the two. But for the well-devised and carefully executed experiments by which these difficulties were cleared up, the whole matter would have remained in the state of uncertainty in which I well remember it to have been, when I first entered on the study of the subject, previously to Müller's experiments.

Having myself been afterward Sir Charles Bell's pupil (in surgery) both in London and Edinburgh, I can testify from personal knowledge that he himself never admitted that his discoveries needed any confirmation whatever; but was always strong in the conviction, not only that he had himself given all needful evidence of them, but that nothing more remained to be done in the physiology of the nervous system. It is not a little significant of his attitude of mind on this subject, that he used to declare his complete inability to understand "what Marshall Hall was driving at"; the doctrine of reflex action independently of sensation being altogether "beyond his comprehension." As this last doctrine, which forms the basis of modern neurology, is one which anatomy could scarcely even suggest, and which nothing but experiment can demonstrate, I hope that Sir C. Bell's opinion of the all-sufficiency of the study of anatomy for the advancement of physiological science may henceforth be appreciated at its true worthlessness. For I have shown, *first*, that Sir Charles Bell, trusting to anatomy for his guidance, *went altogether wrong* in the first instance; *secondly*, that it was by *experiment* on the nerves of the face that he was led into the *right* track; *thirdly*, that in regard to these, through placing too much trust in his anatomical preconceptions, and insufficiently testing them by further experiments, he was led into mistakes which were only corrected by the experiments of Magendie; and, *fourthly*, that the most important discovery with which he is usually credited—that of the motor and sensory functions of the anterior and posterior roots of the spinal nerves respectively—was only *established* in the true scientific sense by the experiments of others working on his lines. Those experiments might have issued, for any real proof ever given by Bell to the contrary, in establishing some other doctrine of the spinal nerve-roots than that to which he had been led by his study of the nerves of the face—such, for

example, as that of Alexander Walker, or that of his own first "Idea."

These assertions are not now made for the first time, with the view (as might be urged) of lowering Sir Charles Bell's credit, and thereby weakening the force of the testimony borne by him in regard to the uselessness of experimentation as a means of physiological discovery. Forty-two years ago, the history I have now sketched (which was then a matter of contemporary knowledge) was told in detail in the leading medical "Quarterly"; the misrepresentations of Mr. A. Shaw as to Sir C. Bell's "Idea" of 1811 were fully exposed; and Bell himself was distinctly charged with having altered what professed to be exact reprints of his papers in the "Philosophical Transactions," in order to make them square with the corrections supplied by the experiments of Magendie. To those charges, so far as I am aware, *no reply was ever made*, either by Mr. A. Shaw or Sir C. Bell; but a new and more correct history, including a reprint of Bell's "Idea," was given by Mr. A. Shaw nearly thirty years later in the "Journal of Anatomy and Physiology" (vol. iii, 1869). Further, in Professor Vulpian's "Leçons sur la Physiologie du Système Nerveux" (Paris, 1866), the history is narrated in terms almost identical with my own, omitting only the reference I have supplied to Magendie's first knowledge of Bell's views, but inserting several of the altered passages in Bell's papers. And, finally, the venerable Professor Milne-Edwards, in his admirable "Leçons sur la Physiologie et l'Anatomie Comparée" (tome xi, pp. 361, 362), has given a most true and just appreciation of the respective shares which Bell and Magendie had in this great discovery.

I have never admitted the truth of the well-worn adage, "A little knowledge is a dangerous thing"; because every one who studies any subject whatever *must* begin with "a little knowledge," and only by its possession can know where and how to obtain more.

But "a little knowledge" *is* dangerous when it leads its possessor to imagine that he (or she) knows *all* about the subject; and is *doubly* dangerous when it is taught as the whole truth to others. And this is exactly what Mrs. Dr. A. Kingsford has done, in her desire to excite a prejudice against physiological experimentation; fastening eagerly upon Sir Charles Bell's depreciation of it, without taking any trouble to ascertain historically what that depreciation is worth.—*Fortnightly Review.*

THE ZUÑI SOCIAL, MYTHIC, AND RELIGIOUS SYSTEMS.*

By F. H. CUSHING

GENTLEMEN OF THE NATIONAL ACADEMY OF SCIENCES—LADIES AND GENTLEMEN: Let me at once present my Indian friends. And now let me introduce some remarks on the mythology and religion of the people whom they represent, the Zuñi Indians of Western New Mexico, the largest of the Pueblo nations, the lingering remnants of a vast culture which gave rise to the cliff and *mesa* ruins of the far Southwest, by a few words designed rather to define my own position than to illustrate my subject.

The student of the natural history of mankind finds his most difficult subject in the mythology of the lower peoples. Even our own mythology, including our theisms and superstitions, is hard to understand, yet ours is, thanks to just such bodies as the one which I have the honor to address to-day, the simplest of all mythologies, because its range of superstition is circumscribed by that of definite knowledge, its theism simplified in proportion to the extent of material philosophy.

Perhaps first among the causes of our difficulty is the fact that all mythology deals with those forces and things in nature which are beyond our comprehension; that it ends not here, but attempts to explain the origin of things in themselves incomprehensible. In proportion, then, to the lack of definite knowledge in any people, its mythology becomes more complicated and less readily understood. To the same intellectual germ in humanity which quickens the philosophy of the nineteenth century may we look for the cause of the origin and growth of mythology. And thus it happens that we find the scientist of our own places and times and the Zuñi Indian laboring hand in hand in the same field, both trying to explain the phenomena of nature and their existence, the one by metaphysical the other by physical research; the one by building up, the other by tearing down, mythology. In order, then, to comprehend the mythology of a people, we must learn their language, acquire their confidence, assimilating ourselves to them by joining in their every-day life, their religious life, even as far as possible in their intellectual life, by remembering with intense earnestness the reasonings of our own childhood, by constantly striking every possible chord of human sympathy in our intercourse with those whose inner life we would study.

I think I have now sufficiently explained why I have entered into relation with the Zuñi Indians, and become a participator in their

* Lecture before the National Academy of Sciences, delivered in Washington, April 22, 1882.

religious practices and, so far as possible, beliefs, to the extent of acquiring membership in their gentile organization as well as in their priesthood ; and my attitude toward the audience before me is that of an imperfect exponent of Zuñi mythology and belief.

Since my return from the Southwest, time has not permitted a sufficient study of those technicalities which have, during the past few years, been introduced into this class of subjects. I shall therefore have to proceed very simply, much as would a Zuñi priest, could he address you, in a discussion of his mythology and religion.

The Zuñi mythology, or theogony, is a reflection of Zuñi sociologic or governmental institutions, with the added feature of an almost universal spiritualistic philosophy. Hence it follows that a discussion of the one must include at least a brief description of the other. Like all well-known tribes of North American Indians, the Zuñis are divided into *gentes*, there being in their nation fifteen distinct clans or gentes. These again are combined into phratries, not political confederacies as among the Iroquois and Muscogee, but ecclesiastical bands, or, in other words, into secret medicine or sacred orders, of which there are, including the wonderful and supreme organization of the Priesthood of the Bow, thirteen. Based upon this sociologic structure, the government of Zuñi embraces three principles, the ecclesiastic, the martial, and the political, the outgrowths of which, in their order of precedence, are the priesthoods or caciqueships, the war chieftaincies, and the political chieftaincies. Supreme in national as well as in ecclesiastical office is the priest, or cacique of the sun, or *Pekwina*, immediately under whom are four secular as well as ecclesiastical high-priesthoods or caciqueships, the priesthood of the Pueblo, or temple of worship—in Zuñi *kia kwe armosi*—with the auxiliary office *tâ shiwan okia*, or "Priestess of Seed." Selected by, yet supreme over the latter four priests in martial and secular matters, are the two high-priests, or caciques of war, who may or may not be at the same time master-priests—*Pithlan shiwan moson atchi*—of the Order of the Bow. These six priests are designated in Zuñi ecclesiastical language "Priests of the Light or Day"; while resident in those special clans, which by heredity furnish the high-priesthoods (mainly the Clan of the Parrots, itself considered consanguineally descended from the gods), are numerous "Priests of the Night or Darkness," any one of whom may be chosen on the death of a priest of the light by the surviving companions. The two priests of war in turn create both the martial and political head chieftaincies, referring the latter to the four priests of the temple for acceptance or rejection. The martial head chieftaincy, or war chieftaincy, includes the third priesthood of the Order of the Bow, thus combining the ecclesiastical with the martial, and explaining the precedence of the latter over the political office. The third priest of the Order of the Bow, or head war-chief, then names three sub-chiefs, themselves necessarily

members of his own order. Likewise the head chief creates his own three sub-chieftaincies as well as the second political head-chieftaincy or chief, who in turn names his own three sub-chiefs. We find, then, that the democracy, or republic, of popular tradition, in its reference to the sedentary Indians of New Mexico and Arizona, is, like most other popular traditions regarding these comparatively unknown peoples, erroneous; that in reality their political fabric is set up and woven by an elaborate priesthood, the only semblance of democracy reposing in the power of the council—itself composed of all adults of good standing in the nation—to reject a political head chief as thus chosen, while the power of choosing a substitute remains still in the hands of the martial priests, and that of confirming him in the hands of the four priests of the temple. The latter are considered the mouth-pieces of the priest of the sun, just as the two priests of war are considered at once the mouth-pieces and, in martial and political affairs, the commanders of the four priests of the temple; and, again, the third priest of war, or head war-chief, and the first political chief, brothers to one another, yet differentiated in their functions, are considered to be the mouth-pieces of the two priests of war, the one in times of national disturbance, the other in times of peace. And yet, again, the sub-chiefs of the war-chief, as well as those of the two political head chiefs, are considered the mouth-pieces of their respective superiors.

Now, the organization of each one of the sacred or medicine orders of Zuñi, less in importance than the order of the priesthood of the bow, is a miniature representation of the national ecclesiastical and martial organizations—that is, each order has its *pekwina*, or high-priest, its four *kia kwe armosi*, or priests of the temple, its two *pithlan shiwan mosun atchi*, or priests of the bow, and in accordance with its special office its medicine or prayer-priest or master, and its sacred council. Less strictly secret, yet more sacred, and organized upon similar though more elaborate principles of office, is the church of Zuñi, the order of the sacred dances, or the *kâ kâ*, which is lodged in six places of worship—the half-underground *estufas* of the north, west, south, and east, the upper and lower regions of the universe. While the *kâ kâ*, as a whole, has its supreme high-priests, its priests of the temple, its warrior-priests, and its prayer-masters, each one of these six temples of worship has also its like special system of priesthood, with the added offices of song-priests or masters. Both in its organization as a whole and in its lesser organizations, the *kâ kâ* seems to be a perfect mirror, as it were, of the mythology of the Zuñi nation, just as the mythology is a reflection of the sociologic organization of the same nation. It is, then, to a study of the organization and functions of the *kâ kâ*, based upon a knowledge of the national sociologic organization, that we are to look for the most complete and clear exemplification of their system of gods, just as we are to look to the tradi-

tional rituals, prayers, songs, and sacred epics of this *kâ kâ* for a comprehensive idea of their mythology. Knowledge gained from both these sources may in turn be vastly added to, strengthened, and corrected by a close study of their most abundant and beautifully imaginative folk-lore.

Supreme over all the gods of Zuñi is *Hano ona wilona*, or holder of the roads of light, corresponding to the earthly *pekwina*, or priest of the sun, and represented by the sun itself. Beneath him is a long line of gods so numerous that I know not half their names, nor have I recorded them, but they are divided into six great classes: the celestial or hero gods (the demon-gods themselves perhaps the vestiges of a more ancient hero-god mythology), the elemental gods, or the gods of the forces of nature, the sacred animal gods, or the *kia pin a hâi* and *kia she ma a hâi*, the gods of prey or *wemar a hâi*, and the tutelary gods, or divinities of places. While *Hano ona wilona* is supreme over all, he himself, like the earthly sun-priest, is limited by his own high-priests among the gods—the celestial or hero gods, and they, in turn, by the demon-gods, while the two earthly offices of head political and war chiefs are represented, on the one hand, by the *raw* or water-wantings beings, or animal gods; and, on the other, by the *wemâr a hâi*, or gods of prey, while the priests of the night in the human organization (*tkwi-na-proa-a shi-wa-ni*) seem to be represented by the tutelar gods of the deistic organization. Not less important, then, because they are supposed to act in connection with the latter, are the ancients, or spirits of the ancestors, who form the body-politic of this great system of gods, and are supposed to serve as mediators between the mortals and the gods. In Zuñi belief they have also a definite place of residence assigned to them, notwithstanding which they are supposed to hold constant communion, even to the extent of occasional materialization with those whom they have left behind, to listen attentively to their prayers, and to represent them in some vague way to the higher gods of the Zuñi mythology.

While this great system of gods, like the *kâ kâ*, is organized, as a whole, not unlike the ecclesiastical and martial systems of the Zuñis, so also has each one of the six systems of gods, like each of the six *estufas* of the Zuñis, its offices of high-priests, priests of the house or temple, warrior-priests, etc. As an example of this special organization, let me speak of the gods of the ocean, who under specific names and attributes are further distinguished as "our beloved *Pe kwi we*, or sun-priest of the ocean; our beloved the *ona ya na k'ia a shi wa ni*, or priests of the temples of the ocean; our beloved mother, the *K'o hak o k'ia*, or the goddess of the white shells; our beloved, the three great warrior-priests of the ocean, *kia chla wa ni, ku pish tai a*, and *tsi k'ia hâi a*, in whom we do not fail to recognize the two master-priests of the bow, and the third priests of the bow, or head warrior-chief of the martial organization. The lesser personages of Zuñi

government are finally represented by the sacred animal gods of the ocean.

Let me give, as illustrations of the deistic conceptions of the Zuñis, without special reference to their rank in this governmental system of the gods, the names and supposed attributes of a few of the principal gods of Zuñi mythology. *Hâno ona wilona*, or the "holder of the roads of our lives," the supreme priest-god of Zuñi mythology, is supposed to hold as in his hands the roads of the lives of his human subjects, is believed to be able (to use the language of a Zuñi) to see (or perceive) not only the visible actions of men, but their thoughts, their prayers, their songs and ceremonials, to will through his lesser deities whether a thing shall be or shall not be in the course of a human life. I once asked a priest in Zuñi, who was about to go forth on a hunt, "Do you think you will lay low a deer this day?" and he said, "*Ooth-lat hâno ona wilona*" (as wills or says the holder of the roads of life). Immediately below *Hâno ona wilona* are the gods *Ahai in ta* and *Ma 'tsai le ma*, the two great deities of the priesthood of the bow, anciently known as *Ua nam atch pi ah ko'a*, the beloved both who fell (for the salvation of mankind). They are supposed to be twin children of the sun, *Hâno ona wilona*—mortal, yet divine. They were the guiders of mankind from the four great wombs of earth, the birth-place of the human family, far eastward toward the middle of the world; but, on reaching the eastern portion of Arizona, in the great exodus of the Pueblo races, they are supposed to have been changed by the will of their grandfathers—four great demon-gods—into warriors, and ever since have been the great gods of the order of the priesthood of the bow, and the rulers of the mountain-passes, and enemies of the world. Just so the young man, in modern Zuñi life, who lives for years in peaceful industrial pursuits, and all at once becomes chosen as a proper person for membership in the Order of the Bow, is induced to take a scalp, and henceforth becomes a ruler of his people and his world, a warrior and a member of that most powerful of priesthoods. These two gods are supposed to have been the immediate ancestors of the two lines of priests who are now their representatives, the high-priests of the Order of the Bow; from them, in one unbroken line, has been breathed the breath of *sa wa nikia*, or the medicine of war, from one to the other of the members of their household, the *a si chlan shi we ni*, or their children, the priests of the bow, just as has been in the belief of the Roman Catholics the unbroken apostolic succession. Through their wills over the *kia sin a hai*, or annual gods, with the consent of *Hâno ona wilona*, or the "holder of the roads of life," are the roads of man's life divided, or the light of his life cut off—figurative expressions for death in the highly poetic language of the Zuñis. Prior to their creation war seems to have been a secondary element in the existence of the Pueblo race; such as it previously was, however, it was represented by the great ancient god of war, the hero

of hundreds of folk-lore stories, *Atchi a la to sa*, or "he of the knife-feathered wings." He is supposed to carry ever about him his many-colored bow, *a ni 'to lan*, or the goddess of the rainbow, to walk upon his swift arrow, *wi lo lo a'te*, turquoise-pointed god of lightning, and to be guarded on the right and the left by his warriors, the mountain-lion of the North and the mountain-lion of the West.

Among other beings of ancient Zuñi mythology we have the marvelous example of *Oohe pololon*, or "the god of the north wind," whose breath sends the cold winds from the north region and drives the sands of the southwestern deserts, which have been stirred up by the will of the gods of the mountain. Dark and gloomy, like the clouds of the north-land home, ferocious with his shining teeth and glaring pendant eyeballs, wild with his iron-gray halo of ever-waving hair and beard, *Oohe pololon* is one of the most terrific of Zuñi demon-gods. Then we have the gentle moon, mother of the women of men, through whose will are born the children of women, the representative in this system of deities of the *Shewan okao*, or seed-priestess, younger sister of the priests of the temple; and the sister of the moon, the beautiful goddess of the ocean, through whose ministrations are awakened the loves of the Zuñi youth, and the good fortune of trade is secured.

While those gods in Zuñi mythology remaining unknown to me are legion, yet I might continue for hours to mention gods and their attributes; as for instance, "he who carries the clouds from the ocean of sunrise to the ocean of sunset and scatters them through the heavens between"; *Kwe le le*, or "he who infuses the roots of all trees with the spirit of fire, and swings his torch in mid-air, and it forthwith bursts into flames"; *Te sha mink'ia*, or "he who dwells in the cañons and cliffs of the mountains, ever echoing the cries of his children, men and beasts of mortality."

Interesting among the hero-gods is the great priest of all religious orders save that of the bow, *Poskai ank'ia.* In the days of the new, yet not until after men had begun their journey toward the east, he is supposed to have appeared among the ancestors of the Zuñis, the Taos, the Coconinos, and the Moqui Indians, so poor and ill-clad as to have been ridiculed by mankind. He it was who taught the fathers of the Zuñis their architecture and their arts, their agriculture and their system of worship, by plume and painted stick; but, driven to desperation by the ingratitude of his children, he vanished beneath the world, never to return to the abodes of men—yet he still sits in the city of the sun, ever listening to the prayers of his ungrateful children.

Let me add one more example: that of *Kia nis ti pi*, or "the great water-skate," who with his long legs measured the extent of the earth as with a compass, and between the oceans of sunrise and sunset determined the center of the world as the home of the Zuñis. He is represented by a peculiar figure, and this introduces us to a new depart-

ment of the subject—the conventional system of pictographs whereby the Zuñi sacred orders illustrate their mythological ideas. It is first to a close study of the mythology and theogony of the Zuñis, and then to that of the conventional forms of art among these and kindred peoples, that we are to look for the key to the mysterious and unnumbered pictographs of the great Southwest.

Interesting for comparison with Eastern mythology is the study of the phallic and the serpent symbolism as they occur in highly developed forms among the Zuñi Indians. Yet, again, interesting because of the light that it throws upon the development of human religions and mythologies is the study of the influence of environment, physical, biologic, and sociologic, as exemplified by the religion and mythology of the Zuñis.

I regret most deeply that in the limited time allowed me to-day I can not go into a discussion of these various questions, and into a production of the hundreds of facts illustrative of them which I have in my possession; but that I have time only to add that, as further illustrative of the connection between the Zuñi sociologic and the Zuñi mythologic systems is the fact that no general names for chiefs of all the departments—ecclesiastical, martial, and political—are to be found in their language, nor is there a general name for their god-priests, hero, demon, animal, elemental, celestial, or tutelar. Yet the term *awa nu thla* includes the political and martial chiefs in Zuñi government, just as does the name *k'ia pin a hâ i* include their representatives, the sacred water and prey-gods, of Zuñi mythology.

ASTRONOMICAL PANICS.

By DANIEL KIRKWOOD.

WHEREVER science has not been cultivated, all new and startling appearances in the sky are regarded as supernatural. But a few years since a shower of meteoric stones fell in India, the fall being attended by terrific explosions. The alarmed inhabitants of the district believed these masses of rock to have been thrown by their deities from the Himalaya Mountains, and with great veneration gathered up the fragments to be kept as objects of religious worship. Nor need we smile at this example of recent superstition. In the most civilized countries of the ancient world such phenomena as the aurora borealis, total eclipses, comets, and meteoric showers, were viewed as miraculous displays of divine power, and generally as forerunners of impending disasters. A brief account of some of the panics thus produced may not be without interest.

No one who has seen the more brilliant displays of the northern

lights—the splendid coronal arch, the columns tinged with various colors and moving in silent grandeur upon the midnight sky—can wonder that in a superstitious age their appearance should have excited the utmost consternation. Before the eighteenth century no physical explanation of such displays had been suggested or even thought of. The phenomena appeared suddenly and unexpectedly, and could not be referred to natural causes then known. The excited imagination saw armies mustering in the sky, brandishing their spears and raising aloft in quick succession their bloody lances. A very brilliant aurora seen in England, in 1575, is described by a writer of that period as a chasm formed in the northern sky, in which "were seen a great many bright arches, out of which gradually issued spears, cities with towers, and men in battle array; after that there were excursions of rays in every direction, waves of clouds, and battles in which some were fleeing, some pursuing, and others wheeling around in a surprising manner." If panics of this nature have ceased, the fact is due to the ever-advancing light of physical science.

One of the most noted eclipses in history is that recorded by Herodotus, and which occurred in the year 585 B. C. The panic produced by this eclipse put an end to the war between the Medes and the Lydians. A great battle was in progress, when, suddenly, day was turned into night by a total eclipse. The contending armies, struck with consternation, at once laid down their arms and hastened on both sides to conclude a peace.

THE ECLIPSE OF LARISSA.—Xenophon, in his "Anabasis," Book III, chapter iv, relates how the excitement and alarm produced by a total eclipse led to the surrender of a city. When the Persians obtained the empire from the Medes, their king besieged the ancient city of Larissa, but failed to capture it till, finally, the inhabitants, terror-stricken by the darkness of a solar eclipse, lost all courage, and so the city was taken.

A total eclipse of the sun was visible at many places in Europe on May 12, 1706. Professor Grant relates, in his "History of Physical Astronomy," that in many parts of the city of Geneva persons were seen during the totality "prostrate on the ground and offering up prayers, under the impression that the last day was come."

An ancient writer, in describing the great meteoric shower of the year 1202, says: "The stars flew against one another like a scattering swarm of locusts, to the right and left; this phenomenon lasted until daybreak; people were thrown into consternation and cried to God, the Most High, with confused clamor." Similar consternation and alarm were exhibited during the great meteoric display of 1366. An historian of that time says, "Those who saw it were filled with such great fear and dismay that they were astounded, imagining that they were all dead men, and that the end of the world had come."

The terror and alarm produced among the colored people of the

South by the great star-shower of 1833 have been so often described that the details need not here be repeated. I may, however, remark in passing that this shower was derived from the same meteoric swarm that produced the displays of 1202 and 1366, to which I have referred, and which returns at intervals of thirty-three years and three months.

In former ages comets were regarded as signs sent directly by the Deity to announce coming wars or fatal disasters. The degree of terror which they excited was proportioned to the size of the comet or the form and length of its train. A great comet, believed to have been that of Halley, appeared in April, A. D. 1066, the year in which William the Conqueror invaded England. This comet was looked upon as the forerunner of the conquest, and produced universal alarm. "The new star means a new king," was the common expression of the day. All writers of that period bear witness to the splendor of the comet of 1066.

But the accounts of all great comets in ancient times furnish similar instances of superstitious dread and consternation. Of a different nature was the alarm produced among the ill-informed in 1832 by the baseless expectation of the earth's collision with Biela's comet. It had been announced by astronomers that on a particular day a part of the earth's orbit would be included within the nebulosity of the comet. This statement was misunderstood by the general public, and a coming together of the earth and the comet was by many apprehended. Astronomers well knew, however, that our planet would be millions of miles from the intersection of the two orbits before that point could be reached by the comet.

The latest instance of supposed danger from a comet is that founded on a misapprehension of an article by the distinguished Mr. Proctor. In 1668 a large comet appeared and passed very near to the sun's surface—probably through the upper strata of its atmosphere. The great comet of 1843 moved so nearly in the same path that it was supposed by some astronomers to be a return of the same body; the period being one hundred and seventy-five years. But the path of the bright comet seen in the southern hemisphere in 1880 coincided still more nearly with that of the comet of 1843, and these dates would indicate a period of only thirty-seven years. Either, therefore, the period is becoming rapidly shorter, or the comets are separate bodies moving in orbits which, within the limits of the planetary system, are nearly coincident. The latter alternative has, I think, the greater probability. The theory, however, that the comets of 1668, 1843, and 1880 were returns of the same body, and that its orbit is converging with great rapidity, has been defended as affording a plausible explanation of the similarity of elements. At a meeting of the Royal Astronomical Society of London, May 14, 1880, Mr. Marth, a well-known astronomer, remarked as follows:

"Supposing this comet of 1843 is the same as that of 1668, it would

not be very wonderful that it should reappear now after thirty-seven years, instead of one hundred and seventy-five years. The velocity of a body moving in the solar system depends simply on its distance from the sun, and on the major axis of its orbit. If the velocity is reduced by a resisting medium, there will be a reduction of the major axis, and there is nothing whatever unreasonable in the supposition that, however weak the corona may be, its resistance would have a very great effect upon the motion of a comet which rushes through it, so that I should not be at all surprised if it should turn out that this comet of 1880 is the same as the comet of 1843 and that of 1668, and that its revolution has been so much affected that possibly it may return in, say, seventeen years."

These remarks of Mr. Marth were some time since quoted by Mr. Proctor, and made the basis of an article which in unscientific circles produced to some extent a most absurd sensation. Mr. Proctor's remarks on the subject have been misinterpreted as indicating the probable destruction of life upon the earth about the close of the present century. His language, however, though somewhat unguarded, expressed no such opinion.

The three comets named above approached nearer the sun than any other known, except, perhaps, that of 1680. In fact, when nearest the sun they actually grazed the solar atmosphere, or passed through its outermost portions. Now, it is well known that the motion of a planet or comet through a resisting medium continually lessens its distance, and hence accelerates its velocity. Messrs. Marth and Proctor assume that the passage of the comet of 1668 through the outer portions of the sun's atmosphere reduced its previously long but unknown period to one hundred and seventy-five years, so that its next appearance was in 1843. The perihelion distance at that date was still less ; the comet met with greater resistance, and the period was shortened to thirty-seven years. The time of revolution would thus be lessened at each successive return, and ultimately the comet would plunge into the sun. Striking the solar surface with a velocity of three hundred and fifty miles a second, the amount of heat produced by the concussion and radiated to the earth might raise the temperature to such a degree as to destroy life upon our planet. Such are the conjectures suggested in Mr. Proctor's paper. Let us briefly consider them.

In the first place, the *fact* on which the theory of the supposed catastrophe is based—viz., the identity of the three comets—is extremely doubtful. It is much more probable, in view of all the circumstances, that they are different bodies moving in similar orbits.

Again, the period of seventeen years, fixing the comet's next return, according to Mr. Marth, about 1897, was the merest conjecture, not founded on any mathematical calculation whatever. It is true that the passage of a comet through the sun's atmosphere would short-

en its period at each return. The absorption of the comets of 1843 and 1880 by the sun's gaseous envelope, at some time in the distant future, is therefore by no means improbable. Such results are not known to have occurred in historic times; but, if the sun is gradually contracting—in other words, if its diameter was once considerably greater than at present—any comet passing so near the center as that of 1880 would have plunged so deeply into the sun's atmosphere as to be absorbed into its mass. It is true, moreover, that, when the motion of a body is arrested, such motion is converted into heat. If the earth were stopped in its orbit, its fall upon the sun would produce an amount of heat equal to that now radiated in ninety years. If the mass of the comet be $\frac{1}{5000}$ that of the earth, the heat produced by the impact would scarcely be equal to that now radiated in seven days; or, if the cometary mass be only equal to that of a globe one hundred miles in diameter, and of the same density as the earth, the additional amount of heat would be less than that now supplied in a single hour. It may further be remarked that the collision would be as likely to occur on the hemisphere turned away from the earth as on that turned toward us.

But let us assume that the great southern comet of 1880 was in fact a return of the comet of 1843, that its present period is about thirty-seven years, and that in consequence of its passage through the outermost strata of the sun's atmosphere its period must be shortened more and more until it falls upon the sun's surface. The solar atmosphere is known to be very rare from the fact that matter thrown out by the sun's eruptive force has been seen to ascend to a height of two hundred thousand miles. The resistance which it would offer to the comet's motion would therefore be slight, and in all probability several centuries would elapse before the comet's course would be terminated by its falling upon the sun. Instead, therefore, of a sudden catastrophe, we should have a gradual dissolution of the comet; portions becoming absorbed by, or incorporated with, the solar atmosphere at each successive perihelion passage. The apprehension of danger to the earth from a great and sudden increase of the sun's heat is, therefore, without any reasonable foundation.

It is due to Mr. Proctor to say that he did not designate the year 1897, nor indeed any other, as that in which the comet would fall into the sun, nor did he express the opinion that the collision would occur at the comet's next return. He merely remarks that, "if already the comet experiences such resistance in passing through the corona when at its nearest to the sun that its period undergoes a marked diminution, the effect must of necessity be increased at each return, and after only a few, possibly one or two, circuits, the comet will be absorbed by the sun." This statement, though perhaps incautiously expressed, is very different from that attributed by unscientific readers to its distinguished author.

THE STEREOSCOPE: ITS THEORY.

By W. LE CONTE STEVENS.

II.

ALL of the forms under which the stereoscope has come into general use have been devised with a view to creating to the utmost the illusion of natural binocular perspective by reproducing as nearly as possible the conditions of natural vision. That this end is not successfully attained is painfully felt by those who linger too long over an attractive collection of stereographs. To secure comfortable vision the muscles of the eyes must suffer no unusual strain. It is not easy to explain briefly how such strain is necessarily implied in the use of this instrument. Suffice it to say that, in looking at a point a few inches distant, the ciliary muscle which surrounds the crystalline lens in each eye is strongly contracted, and so is the muscle on the inner side of each eyeball. These contractions usually accompany each other, and to dissociate them is always more or less painful. The stereograph is but a few inches distant, but, because there are two pictures, the convergence of the visual lines is much less than normal; indeed, optic divergence is not unfrequently necessary. The unconscious interpretation which is put upon the retinal sensation is due partly to imagination; but also largely to the temporary condition of the muscles of the eyes. This includes not only the ciliary but also the rectus muscles, external and internal, by which the eyeballs are controlled, as the angle between the visual lines is varied. The effect of varying this angle is best studied with a modification of Wheatstone's stereoscope, which the writer has constructed for this purpose. A pair of conjugate pictures are chosen, which present as little as possible of mathematical perspective. A stereograph of the moon, divided at the middle, is one of the best for this purpose. The twin photographs are placed upon cross-bars (Fig. 12) which rest on graduated arms that are pivoted at the proper point in the base of a cubical block to which the mirrors are cemented. These arms move in contact with part of a circle, marked off in degrees at the circumference, the center of this being in the pivot. If the two arms make a straight line, and the pictures are properly adjusted, the visual lines must be parallel, for the eyes to receive the reflected rays. If pulled forward toward the observer, the visual lines must converge in order to retain single vision, and the angle of convergence is at once obtained from the circle. If pushed slightly back, as represented in the figure, single vision can be retained only by optic divergence. Most eyes that are healthy will be found capable of enduring a few degrees of such divergence. The real distance of the object is thus kept unchanged, and the card appears always directly across the visual line. The varia-

tions in apparent size and distance of the binocular image are very striking, while the perspective in the picture remains clear but also variable. If the stereograph be that of a reversed cone, this becomes apparently shallow, small, and near, or deep, large, and remote, ac-

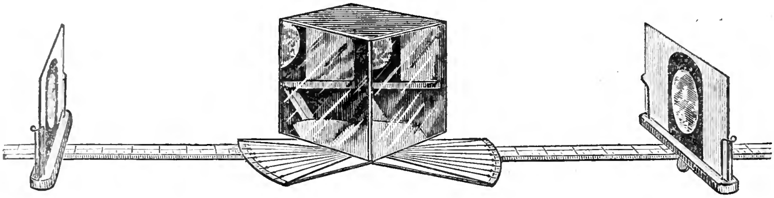


FIG. 12.—THE GRADUATED REFLECTING STEREOSCOPE.

cording as the excess of strain is upon the internal or the external rectus muscles. This instrument, indeed, is useful in quite a variety of binocular experiments. The visual effects are the same as those from an adjustable stereoscope with semi-lenses, but the limits of variation are far wider, and it is a decided advantage to obtain direct measurement of the optic angle.

Such experiments show very conclusively that the current theory of visual triangulation, whatever may be its application to normal binocular vision, has to be entirely discarded as an explanation of stereoscopic vision. As a theory it is beautifully simple, and at first glance appears eminently satisfactory; the only objection to it in relation to the stereoscope consists in the fact that it is untrue. Its expression may be found in most of our text-books of physics, and the diagram usually employed in explaining the stereoscope is that of Fig. 13, which is taken from Helmholtz's "Physiological Optics," the only change being in the avoidance of Greek lettering. This slight change also is made in the following translation from the French edition of this work, which received the last corrections of the distinguished author, who is universally recognized as the highest living authority on the subject of which it treats. After describing the arrangement of the prism-like semi-lenses, he writes: "The two drawings are placed, side by side, upon the same sheet. The right eye, R, looks upon the drawing, *a b*, through the prism, *p*; the left eye, L, looks upon the drawing. *a' b'*, through the prism, *p'*; the partition, *g*, prevents each eye from seeing the drawing intended for the other. The rays, *c p* and *c' p'*, sent forth by the drawings, are refracted by the prisms, following the directions *p* R and *p'* L, the prolongations of which cut each other at C. The convexity of the surfaces of the prisms has the effect of diminishing at the same time the divergence of the sheafs of rays, so that each eye sees at A B an image of the drawing that is presented to it. The object appears in relief at A B."

This explanation is distinctly geometric, the locality of each point of the image perceived being determined by intersection of visual lines,

R C and L C, as the attention is successively directed to different points in the field of view. If accepted at all, it must be accepted fully. If we suppose the semi-lenses removed, and that R and L together represent a binocular camera, the diagram shows the exact relation between this and an object to be pictured, and the admirable mathematical discussion which Helmholtz gives subsequently in full is strictly applicable. But, if the observer's eyes be too near together, or the stereographic interval be too great, the relation between the visual lines ceases to be the same as that between the camera axes, and we no longer have the conditions under which the geometric discussion can be applied. It is but due to Helmholtz to add that he closes with the following remark: "These conditions are not generally fulfilled for the photographic proofs and the stereoscopes of commerce." The same credit can not be given to the writers of the ordinary text-books. This qualification is of the last importance, for without it the theory is absurd, the apparent position of the image determined by intersection of visual lines being *behind the observer's head* when optic divergence is induced, and at an *infinite distance* when they are parallel. But, even when camera axes and visual lines bear the same relation among themselves, the abnormal muscular condition necessitated in stereoscopic vision introduces a disturbing element. The theory is hence not applicable at all to the stereoscope, but must be limited to the discussion of the binocular camera.

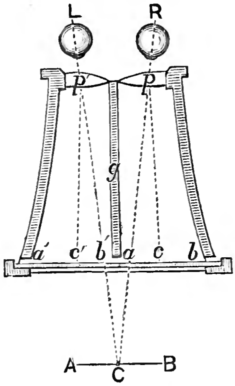


Fig. 13.—Theory of Visual Triangulation.

With a view to enabling persons with untrained eyes easily to perform many of the experiments through which variation in appearance of the binocular image is produced by varying the conditions under which the same stereograph is viewed, the writer has devised an adjustable stereoscope (Fig. 14), which presents the additional very important advantage of rendering vision as nearly painless as it can be with the ideal stereograph, even although the stereographic interval on the one employed be so great as to produce only confusion, or strain of the eyes, when the common form of stereoscope is used. Instead of being fixed in position, the semi-lenses are lightly rested in a pair of boxes, with openings in front and rear so as to transmit the light. Attached to the partition between them are a pair of springs against which the thin edges of the semi-lenses are pressed by adjusting-screws in contact with their thick bases. By turning these so that the glasses are pressed as close as possible together, the light which enters the eyes passes through the thicker part of each glass, where the planes that may be supposed to touch the opposite curved

faces are nearly parallel. The rays are hence but little deviated in transmission, and the condition is the same as that in the ordinary stereoscope. Vision is then as comfortable as can ever be expected, when the stereographic interval is less than three inches. If it exceed this limit, the pain produced by the muscular strain of optic divergence, which would now be necessary, is prevented by giving a few

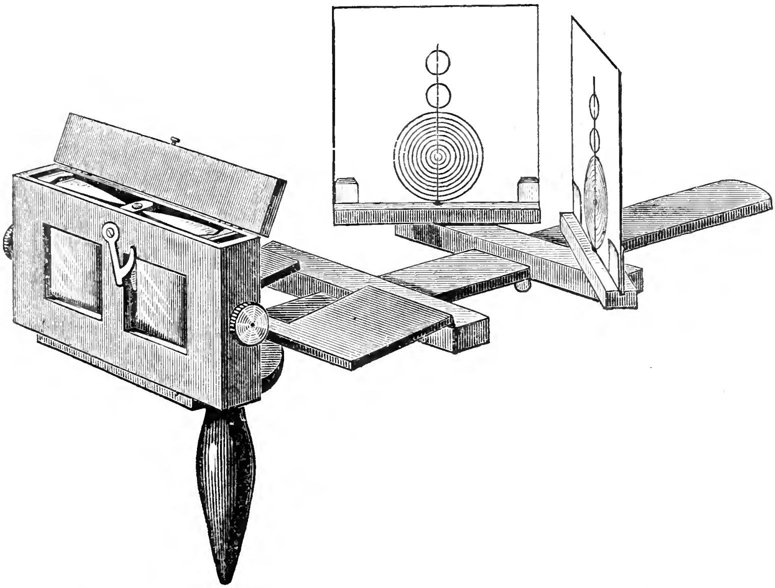


Fig. 14.—The Adjustable Stereoscope. Adjustment for Natural Perspective.

leftward turns to each screw. The semi-lenses are at once pressed farther apart by the springs, the rays pass through at points where the opposite surfaces are more inclined to each other, and they are hence more deviated, so as to enter the eyes still without imposing the necessity of divergence. Indeed, if the stereographic interval be small, and free play be given to the springs, uncomfortable convergence may be induced at will. Under this condition a stereograph may be employed on which the interval is as great as four inches. If, while viewing the combined image, the semi-lenses be screwed closer together, the eyes will continue to adapt themselves, while fusion of images is retained, and any degree of divergence is thus induced that the observer may be disposed to endure. If the stereograph has been properly selected to illustrate the effects of muscle-reading, the image will appear to increase in depth as the visual lines diverge.

In front of the partition between the lens-cases are a pair of folding metal screens, of such width that when pressed flat against the wood they will hide from each eye the picture on the side belonging to the other, but when folded, as shown in Fig. 15 *s*, the whole stereograph becomes visible to each eye. On a movable cross-bar there is

another folding-screen of wood, which is shown pressed down in Fig. 14, and raised in Fig. 15. In the former condition it does not obstruct any part of the field of view, but in the latter it hides from each eye the half of the stereograph on its own side, and permits that on the other side to be seen through the opening at the middle. By now lifting the cover of the cases containing the semi-lenses, these glasses may be removed, and their places supplied with a pair of wedge-shaped prisms, which are introduced with their bases, instead of their sharp

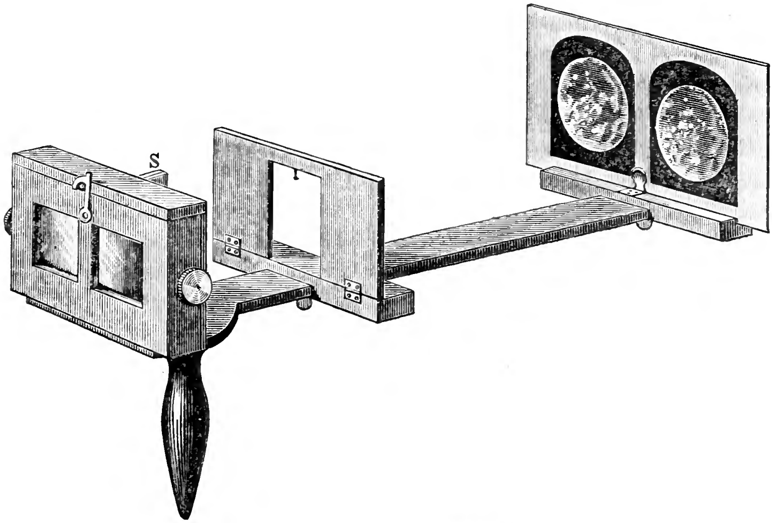


FIG. 15.—THE ADJUSTABLE STEREOSCOPE. ADJUSTMENT FOR REVERSED PERSPECTIVE.

edges, against the springs, while the screens are arranged as in Fig. 15. Pushing the cross-bar, intended to hold the picture, out to the farther end, a stereograph is put upon it that has been specially selected to show the effects of binocular perspective. Any stereograph in which mathematical perspective is not strong may be employed—that of the moon is excellent. Looking at this now through the prisms, instead of appearing convex it presents the aspect of a lustrous hollow hemisphere of crystal, through which on its farther side are seen the familiar dead sea-bottoms and jagged volcanic ridges. Our prisms and windowed screen have apparently turned the moon into a cup by bringing into each eye the picture originally intended for the other. On folding down the windowed screen, two extra moons spring into view. Comparing the middle concave image with the flat ones upon the two sides, it appears smaller and nearer, and this disparity is increased by pulling the stereograph nearer. As it approaches it grows shallower and slightly elliptic, the horizontal diameter becoming shorter; for, as the card is brought nearer, its plane becomes more oblique to the direction of the rays, which leave it to be refracted by the prisms before entering the eye. To the combined cyclopean eye, while each circle

must appear as an ellipse because viewed obliquely, the illusion is that there is no obliquity of vision, but that a narrow cup is suspended directly in front; while the pictures that are really in front of each separate eye appear, without relief, out at the two sides.

If the attention be carefully directed successively to the foreground and background when binocularly viewing a properly constructed outline stereograph, it will be found that perfectly distinct vision of the whole picture at any given moment is not usually possible. The distance between corresponding background points exceeds that between similar foreground points. This excess we shall call the stereoscopic displacement. If it be considerable, a pair of corresponding background points must be seen double, or imperfectly combined, when the foreground is distinct. In transferring the attention, then, to the background, slight associated contraction of the external rectus muscles is necessary to secure perfect combination of corresponding points, and this instantly suggests the idea of greater distance for these. Thus, as the attention is given to different parts of the picture, the tension in the muscles of the eyes is continually varying, and this is one important element in determining our binocular perception of solidity. Unless the attention be very carefully given to it, we are apt to overlook the successive duplication in different parts of the field of view. If the stereoscopic displacement be small, the perception of such duplication may be quite impossible, while the appearance of solidity, or of perspectiveness, as it has been called, remains distinct. The stereograph, represented in Fig. 16, has been specially constructed to exhibit a variety of different stereoscopic displacements. It may be viewed either with cross-vision, or with the aid of a card placed edgwise upon the triple line at the middle, or by placing the page in front of the semi-lenses of a stereoscope. Supposing the last of these methods to be employed, there will be seen at the top of the field of view a truncated cone, with a dot at the center of its lower base, and a pair of projections from the circumference of the

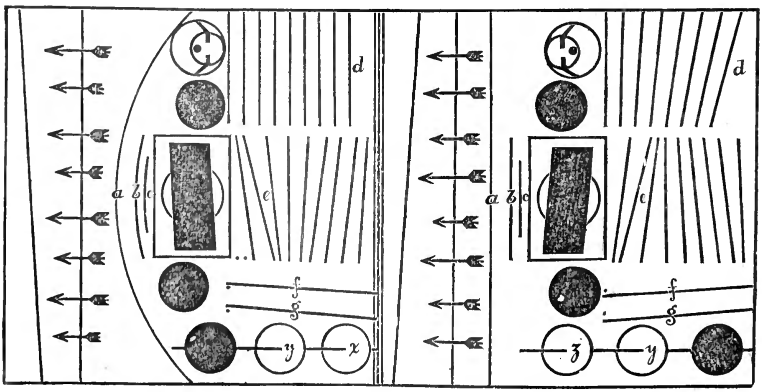


FIG. 16.—STEREOGRAPH ILLUSTRATING THE BINOCULAR COMBINATION OF LINES.

upper base. When the latter is made an object of attention, two dots are seen on the lower base, which apparently broadens out on the two sides; but the moment the attention is concentrated upon them, unless the observer is a little skilled in indirect vision, they fuse into one, and four instead of two projections are seen at the upper base, which in turn has broadened out. Indeed, very little skill is needed to perceive the distinct duplication of the entire upper base. At the middle of the field of view is an inclined black parallelogram, on which no duplication of any part can be perceived, except by a very steady gaze or by comparison with the black circles above and below; and these in turn are made to appear at different distances from the observer. The circular arc and straight line, each marked *a*, combine into a distorted parabola, in which the concavity is perfect at the middle, but at the top and bottom it breaks into two separate lines. The resultant of the lines marked *b* is quite as distinctly curved, but many persons will fail to notice any duplication at all; and this remark applies still more forcibly to the resultant *c*. The group *d* forms a warped surface; but, if the resultant line at its right be fixedly examined, it will be seen as an oblique cross, the combination being effected only by motion of the eyes. The group *e* presents still greater difficulties. The pair *f* are nearly horizontal, and are coalescent at the middle, but not combined at the extremities; each component hence appears no longer straight. The arrows at the left point obliquely, some toward and some from the neighborhood of the observer; but, if the gaze be rigidly directed to the vertical rod on which they are fixed, a pair of well-practiced eyes will perceive some of them to have very mobile double heads. The circles *x*, *y*, and *z* have a common axis, and are successively nearer to the observer; *x* and *z* are highly lustrous, and, when either is regarded separately, *y* is by indirect vision seen slightly double.

The two halves of this stereograph are strikingly dissimilar, but the principle which it illustrates enables us to secure stereoscopy with a pair of absolutely similar figures by so adjusting these in position that advantage may be taken of the almost spherical surface of the back of each eye. The geometric explanation of this is unsuited to the present article.* It may be sufficient to state that, if the two pictures be oppositely inclined to the visual lines, instead of being directly across these, the retinal images must be dissimilar, and the subjective combination of these must hence present the appearance of relief, which may be varied at will by varying the inclination of the cards.

The theory of associated muscular action which has been illustrated, while undoubtedly true, is still not sufficient by itself to explain all the phenomena of stereoscopy. The perception of distinct relief is possible when the card is illuminated with the electric spark. No motion of the eyes is attainable during so minute an interval. It is

* See "American Journal of Science" for April, 1882, p. 297, and May, 1882, p. 359.

possible also, when the stereoscopic displacement is so small, that not the slightest duplication of images can be distinguished with even the keenest vision. When this displacement is large, the play of the eyes is necessary to the completeness of the perception; but, in any case, the illusion is complex. The perception of double images is doubtless one important element; but when these are too minute to be distinguished, we are driven to other resources for an explanation.

Every one has noticed that each instrument in an orchestra has its own peculiar quality of sound, each singer in the cast of an opera his own vocal timbre. The explanation of this is no longer a mystery since Helmholtz analyzed, by the aid of resonators, what had eluded analysis by the unaided ear, and showed that the difference in quality between tones, nominally the same from different sources, is due to minute modifications upon sensations, corresponding to small air-waves accompanying those which produce the fundamental tone. By a well-known system of graphic representation, let the curve in Fig. 17 stand for the fundamental note; if this be simple, the curve is perfectly regular. But in fact it is accompanied by a group of smaller waves

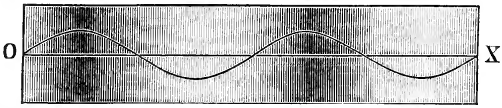


Fig. 17.—Simple Sound Waves.

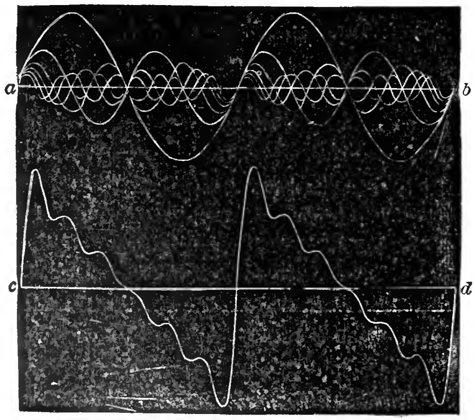


Fig. 18.—Complex Sound Waves.

(Fig. 18, *a b*); when all are graphically combined, the curve is modified (Fig. 18, *c d*), and so is the actual sensation. With the same fundamental a different series of overtones would have produced a different resultant curve and sensation. The first of these resultants may represent c' from a soprano's voice, the other c' from that of the tenor, each sending into the ear 264 complex thrills per second. Without being absolutely unisonant, they constitute a pair of dissimilar musical

sounds that coalesce harmoniously. A well-trained ear may pick out some of the overtones without the aid of resonators, and perceive in the background a few duplicated sound-images; but the great majority of them are so faint that their presence can not be perceived apart from each other, or from the fundamental to which they give character. The rich combination of all stands out in strong musical relief, compared with what each voice alone would yield, or with the sweet but thin sound of a tuning-fork that sings forth the same fundamental pitch.

This principle relates to the combination of sensations, whatever may be the cause of dissimilarity among the components of the group. We have not the data from which a binocular image can be graphically expressed as a curve, for the dissimilarity of the components is not due to interference of waves of light. But the facts suggest kinship between the modes of sensation in the two cases. The dissimilar groups of light-images arouse sensations that are simultaneously conveyed to the brain, and the proper interpretation at once comes as the product of past experience. All we can affirm is, that experience has taught us to interpret retinal sensations which are slightly different in the two eyes, as the signs of an external object possessing three dimensions in space, when the images are produced upon parts of the concave surfaces which bear to each other the relations that would be imposed by the presence of such an object if naturally viewed. Such experience has been acquired by each of us individually, and probably with exceeding rapidity in consequence of inherited tendencies. It is therefore not necessary that the localization of what we see in the stereoscope should be limited to cases of optic convergence, or the perception of relief to those in which double images can be distinguished.

Our discussion has led us from the domain of physics to the confines of metaphysics. Explanations are at best only relative, and the psychologist, the physiologist, and the physicist must join hands in working out the problems of binocular vision. The progress made during the last half-century invites the hope that much may yet be accomplished before the next century brings us its morning greeting.

THE JEWS IN EUROPE.*

By Dr. J. von Döllinger.

I.

THE Academy celebrates to-day the birth of its royal head and gracious protector. Such a festival is, first of all, devoted to feelings the simplest, purest, and most elevating—love, reverence,

* Anniversary Address before the Academy of Sciences at Munich, delivered July 25, 1881. Translated by Mr. W. M. Salter.

gratitude. But it is also an occasion on which we are glad to think of our sovereign as weighing and pondering the affairs of his people, and the general condition of Germany; and passing under review the most important events of the time, carefully measuring their gravity. And so our thoughts turn naturally to the most recent events, to the serious problems, which are now pressing with so loud and urgent a voice upon our attention.

Not the least of these is the Semitic question, which has been agitating Germany for some years. The parties stand sharply over against one another, and as, in the thirteenth century, the cry was "Here Guelph, there Ghibelline," so now there sounds through the German lands, "Here Semite and friend of the Semite, there anti-Semite." With no little astonishment have we perceived that the conflict rages most violently just in the principal city of the empire, and even among those belonging to the aristocracy of culture. And, although the south of Germany is thus far much less involved in the agitation than the north, the forces in motion there are not without influence in our own vicinity. In our days, science may no longer, as was formerly the case, keep aloof in self-contented attitude from the great mart of life; rather has it the strongest reasons for participating, with the ripest results it has reached, in the solution of the problems of our age and nation, and for allying itself, to the end of mutual advantage, with all clarifying and quickening social forces.

So let one of the offerings presented by the Academy, on this the natal day of its royal protector, be an attempt to show how these things have come to be: how the knot, the manner of whose loosing no one is now able to indicate, has gradually twisted itself; and how History, wise guide of life that she is, holds up to the new errors that are threatening us the warning mirror of the errors of the past.

The fortunes of the Jewish people make, perhaps, the most impressive drama in the history of the world.

The Greek tragedians dwell with predilection on the *Hybris*, the arrogant misuse of power, as the dark fate that draws men on to destruction. In the fortunes of this people we encounter, as it were, an *Hybris* made up of religious fanaticism, vulgar avarice, and instinctive race-aversion. It was the result of that moral and intellectual infirmity which, for many centuries, has affected the highest as well as the lowest classes, and which still to some degree exists in wide circles, although kept in bounds by custom, fear, and public opinion. This infirmity was and is, in a word, a lack of the sense of justice.

We know well the powers that still to-day, in every possible form, whether open or disguised, are constantly repeating this one thought: "We alone are in possession of the full and saving truth, and therefore everything must be conceded to, and everything permitted us, that is necessary or serviceable in spreading and putting forward this truth." Where this principle prevails, and it did prevail in the entire thousand

years from 500 to 1500 A. D., and is still affirmed by those who adhere to the mediæval view of things—there even the idea of justice must appear as a damnable illusion. Such justice, we mean, as enables us to judge of men according to their education, inclination, and prejudices; as leads us to enter into the circle of their thoughts and sympathies, and to treat them accordingly; as leads us to excuse and bear with their departure from the lines of our own thinking, believing, and doing, and to respect their independence. The Christian religion has comprehended this justice in the command to love our neighbor as we love ourselves; but, by the rulers as well as the masses, by the teachers as well as the taught, by the educated as well as the ignorant, this supreme command has been misunderstood, ignored, and transgressed to an almost immeasurable extent.

As to the present condition of affairs in this regard I do not propose to speak. It is, however, easy to see that the civilization of a nation ranks the higher, the greater the number of those in it who are permeated by this higher spirit of justice, and the more calculated its institutions are to protect and manifest it. Where the relations of men to one another touch the religious field, we are accustomed to call the lack of this virtue fanaticism; and there have been times when even the best men and the noblest characters have thought and acted in a fanatical spirit. And so it has come about that, in judging of the past, we, on our part, are now called upon to display this justice to just those who were untrue to it in life, and denied it to their fellowmen.

Already, before the destruction of their capital and national sanctuary, the Jews were the most wide-spread of all peoples, and, when Strabo said that there could not be found one place in the world which did not harbor Jews, he spoke of a world comprising all the lands about the Mediterranean, and extending, in Asia, as far as into the Perso-Parthian Empire. By reason of transportations *en masse*, of half-free, half-compulsory colonization, of wars, and commerce in slaves, and gradually also because their spirit of enterprise took the direction more and more of commercial pursuits, they had become a *diaspora*, which, while numerous particularly in the sea-towns, using for the most part the Greek language, and influenced on many sides by Greek culture, still everywhere held firmly together, and preserved its existence as a distinct community. Like other inhabitants of the empire, they enjoyed the benefit of the protection of the Roman law. In general, they were esteemed and even given preferment, rather than mistreated, by the emperors. Their elders, indeed, received certain immunities; firmly holding together, and helping and advancing one another, they were successful competitors in all branches of industry, *therefore—hated.* And if their rite of circumcision, their celebration of the Sabbath, their laws respecting food, and their shy habits of seclusion, excited much derision and contempt, there was still in their

cultus of the one purely spiritual God, who was represented by no image, a powerful attraction for the minds of pagans, who were surfeited with the numberless divinities of their religion. "Enemies are they of the gods as well as men"—such was the frequently pronounced judgment of the pagan populace on this nation, whose character was so mysterious to them. About the time of the Roman war in Judea, they fell, not seldom by thousands, as a prey to the fury of the heathen populace.

They won again, however, a center of religious life and a head: in the little town of Jamnia, in Palestine, the sanhedrim formed itself, whose presiding officer was honored and recognized as the patriarch of the whole nation; so there was at once a supreme authority and an academy.

But just at this time, and in consequence of the powerful influence of the zealots, which had been enormously increased during the late wars, Judaism withdrew convulsively within itself, the Pharisaic way of thinking became exclusively predominant, and cast out every foreign element, such as Hellenism and Essenism; while the Talmud, which held all the members of the Jewish body together and lay like an iron band about the nation, completed the separation, and all the more surely since the Roman laws forbade any to be circumcised who were not of Jewish birth.

However, the question of vital moment was, what attitude those who carried the future in their bosom—viz., the Christians—would assume toward the Jews. The earliest Church remained true in this respect to the example and word of its Master and the teaching of the apostles. It believed and taught: 1. That the death of Christ, for which the leaders of the Jews and a part of the people at Jerusalem were responsible, involves in no way the continuous guilt of the whole nation. On the contrary, Christ himself asked for the forgiveness of his crucifiers, and his prayer was heard. Peter, too, like his Master, excused their transgression on the ground of their ignorance. 2. The people is by no means outcast from God, even if their dispersion, the downfall of their state, and the destruction of their temple and capital, may be regarded as a divine punishment. *Israel remains the chosen people of God*, since God can not retract his choice and promise. At some future day, when the "fullness of the Gentiles" shall have come, the fullness of Israel will also believe, and make an harmonious fellowship along with Gentile believers.

Starting from this view drawn from the New Testament, the wisest and most eminent teachers of the Church exhorted that the Jewish people must be regarded as a brother who has for the time gone astray, but will sooner or later return to the Father's house, and in the mean time is always and will remain the bearer of irrevocable promises. Hence, they marked out the duty for Christians of indulgent and patiently enduring love toward the race, of which both Christ and the apos-

tles were members, and from which they did not wish to be separated. The most learned and original of the older fathers, Origen, declared: "They are and remain our brothers; but they will only unite with us when we, by our faith and our life, have stirred them to emulate our example." Even Augustine frequently said: "In the hearts of Christians the confidence lives, and is expressed by them continually, that the children of the present Jewish generation will some day melt into one faith with the Christians." This view of the earliest Church disappeared, however, when Christianity became the *state* religion, and Roman heathenism *en masse*, with its hate and contempt for the Jews, became converted, in part freely and in part through direct or indirect compulsion, to Christianity. Soon the synods forbade eating with a Jew; and Ambrose, who, while still unbaptized, was elevated to the bishopric of Milan, styled the burning of a synagogue in Rome by the populace an act pleasing to God, and called the Emperor Maximus, who desired its rebuilding, derisively a—Jew. There comes to be, with infrequent exceptions, a more hostile strain in the writings of Christians, and the name of brother vanishes; their remaining without the Church is explained no longer by ignorance, but by an ill-meant obduracy on their part. The hope of a future reconciliation is, indeed, held; but the reconciliation is placed as it were in the most distant corner of the future, in the last days before the final catastrophe and the judgment of the world. It seemed as if the prospect of living in community with Israel (when, moreover, according to the Biblical doctrine, Israel would retake the ancestral primacy) was so little to the taste of the Christians that they were anxious to restrict so unwelcome and vexatious a condition to a few days or months.

The Christian emperors had changed nothing of importance in their laws respecting the rights and liberties of the Jews until the year 439, when Theodosius II excluded them from all public, even municipal, offices. This law passed over into Justinian's Codex, and regulated their status in Europe as well as in the Eastern Empire.

In the West we encounter at the end of the sixth century the first forced conversions in the Frankish Empire; Avitus, in Clermont, and the kings Chilperic and Dagobert set the precedent. It was followed in the kingdom of the Spanish Visigoths on a large scale. There, where the bishops ruled the state, King Sisibut in the year 612 allowed the Jews only the choice of emigrating or being baptized. Many chose the latter, but turned back after a time to Judaism; and, as the result, there began a series of violent measures to keep them in the Church against their will, and to avenge their lapsing. This was in accordance with a decree of the national synod of Toledo—a fatal decree, which has cost more blood and tears than any law of heathen antiquity, since it served as a norm for innumerable deeds in subsequent time.

In the Frankish Empire the ordinances of the Episcopal councils

remained for a long time within the circle defined by the Emperor. The Jews were forbidden marriage with Christians, the ownership and sale of Christian slaves, and jurisdiction in court over Christians; further, Jews and Christians were not allowed to take a common meal, and the employment of a Jewish physician was forbidden. Bitter hostility against the Jewish people is breathed first in the Frankish Empire in the writings of the Archbishops Agobard and Amolo, of Lyons, about the year 848; the latter recommended Sisibut's action as one acceptable to God, and worthy of imitation—a bad sign of what was to come. However, these writings also indicate, first, that at that time the charge of a usurious fleecing of the Christians by the Jews was not yet brought forward; and, further, that the Emperor, the officers of state, and even the agricultural population, were well-disposed to the Jews, and that the state still protected them.

But with the end of the eleventh century a turn of things began, which proved full of disaster to the Christians as well as to the Jews and the pagans. The highest authority in the Western world had announced the principle of the religious wars, and found the means to foster them and continuously excite them anew. It had become an expiatory and saving work to conquer non-Christian peoples, and to plunder and destroy those who resisted; hence, it was unavoidable that the condition of the Israelitish people should take a much worse shape than before; and, although in general Europe was making steady progress in the formation of orderly civil governments, this progress was of no advantage to the Jewish people; rather did each century, until the Reformation, bring an increase of their misery. For the Israelite was in the eyes of the then existing Christians worse than an unbeliever; he was called in the official language of the Church *perfidus*—i. e., a man who deserves neither truth nor confidence. "Oremus et pro perfidis Judais" stood in the Liturgy for Good Friday, and all theologians and canonical writers of that time used the expression. The Jew should be avoided like one afflicted with a plague, even whose breath contaminates, or like a dangerous tempter, whose words hide the poison of doubt and unbelief. The laity were forbidden to speak even one word with him on the subject of religion.

When, therefore, the hosts of the Crusaders went out to war against the Mohammedans in Asia, they began slaying the Jews at home, and plundering their houses. And the kingdom of Jerusalem began its existence by burning the Israelites who lived there, together with their synagogues.

Those were acts of fanatical and untamed bands. For princes and peoples, for priests and laymen, the utterances of the Popes and councils respecting the rights and duties of Christians to the Jews were naturally accepted as giving the law. Before this, the Roman bishops had not concerned themselves about the Jews; their epistles and enactments during the first six centuries contain nothing about them, the

imperial laws appearing to have satisfied them. Gregory the Great protected them unweariedly against the acts of violence common in Southern Italy, and forbade forcing them into the Church. On the other hand, he sought to procure their conversion by vouchsafing privileges to them, and set up the doubtful principle, which was often evoked later on when forcible conversions were attempted, viz., if the Church does not win thereby those who have been bought over, it certainly wins their children.

From that time on, for nearly three centuries, the Popes are silent respecting the Jewish people. After the middle of the ninth century the first considerable assumption of power on the part of the Papacy took place under the Pseud-Isidore, Nicholas I, and his nearest successors. When Stephen VI (885–891) broke the long silence, a strong hostile feeling had already taken the place of the earlier mildness in Rome. The Pope wrote to the Archbishop of Narbonne, that "he had been plunged into deadly anxiety by the news that the Jews, those enemies of God, had become possessed there by royal permission of property in land, and that Christians lived together with these dogs, and even performed service for them, although, as a punishment for the death of Christ, all the pledges and promises which God had confirmed to them were canceled." With this the signal was given, and the new path entered upon on which men now proceeded to advance. It is true that the Jews were not seldom successful in obtaining Papal letters of protection. The injunction not to force them to baptism, or to rob or kill them, was often repeated; but, while on other occasions, even in matters of little consequence, banning, interdicting, outlawing, and other drastic means were threatened and applied, these bulls for the protection of the Jews consisted of general exhortations, and were of little use, because the penal sanction was wanting. The kings and high nobility set everywhere the example of lawlessly oppressing, abusing, and plundering the Jews, and we do not find that the Popes called them to account for this, or took the part of the oppressed against them. On the contrary, when Philip Augustus robbed and banished the Jews of France, Cœlestin III declared that the king in doing this had shown his ardent zeal in the cause of God; and when any temporal ruler, who was also an official in the Church, in order to be sure of his right to do so, asked for Papal authorization to drive out the Jews from his dominion, it was readily granted him. The declaration of Innocent III, that the whole people was condemned by God, on account of its guilt, to perpetual slavery, became the oft-cited Magna Charta for all those whe lusted after the gains and possessions of the Jews; in accordance with it rulers and peoples acted. Nor could the impression it made be greatly diminished by the circumstance that the Popes supported the letters, which they from time to time gave for the protection of the Jews, by referring to the prophecy about a remnant of the people that should remain

over, in order to be converted in the last days. Such a remnant of the Jews, it was thought, would be preserved, if not in Europe, at all events in Asia.

The succeeding Popes held firmly to the principles and demands of Innocent III. If the Jews built a new synagogue, it must be torn down; the only thing allowed was to repair the old ones. No Jew could witness against a Christian; the bishops were to insist, even with the use of force, upon their wearing of the distinctive badges, the hat or the yellow cloth. This law respecting badges was particularly hard and cruel; for, in the frequent uprisings and tumults in the cities, the Jews fell so much the easier into the hands of the infuriated mob, which in this way recognized them at a glance; and in traveling they became the prey, without hope of rescue, of the robber-knights and highwaymen, who naturally looked upon every Jew as an outlaw. In Spain, permission was therefore given them to wear every kind of clothing in traveling, but the permission was soon taken back.

Especially did Eugene IV, who annulled the humane concessions made by Martin V, add to the sharpness of the ecclesiastical legislation, already pitiless enough, and the question was perforce raised how, if all this was fully carried out, could these men maintain their piteous existence at all.

Whatever ground the Popes had left untouched, was covered by the councils of the different countries; they forbade, for example, that a Christian should let or sell a house to a Jew, or buy wine of him. In addition to all this, came the oft-renewed orders to burn all copies of the Talmud and its commentaries—i. e., by far the largest part of the Jewish literature—on account of the passages hostile to Christianity that were said to be found therein. And then came again tortures, persecutions, and imprisonments in abundance. It seemed as if the mighty of the earth had only stones instead of bread for the afflicted people, and were disposed to give no answer to their entreaties and inquiries, other than that which the ancestors of the Jews once gave to the tyrant Herod, viz., when he asked what, then, he should do for them, they replied, to hang himself.

The new theory of the slavery of the Jews was now adopted and elaborated by the theologians and canonical writers. Thomas of Aquinas, whose views pass as unimpeachable in the whole Church, decided that the princes could dispose of the property of these men, who were condemned to perpetual bondage, just as they would of their own goods. A long series of writers on the canon law built upon the same foundation the assertion that princes and lords could forcibly dispossess the Jews of their sons and daughters, and cause them to be baptized. That a baptized child of a Jew should not be allowed to remain with its father was universally taught, and still is a demand of the Church. The princes, in the mean time, had greedily adopted the papal doctrine of the divinely ordained slavery of the Jews, and the

Emperor Frederick II based thereupon the claim that all Jews were his property as the Emperor, according to the then prevailing logic, that the master's rights over them had been transmitted from the old Roman emperors to him as their successor. His son, Conrad IV, already used the expressions, "servants of our chamber," and the *Schwabenspiegel* * professed to know that "King Titus had given them over to be the property of the imperial chamber." King Albrecht demanded from King Philip of France that the French Jews be handed over to him, and later the Jews themselves said, in a memorial to the Council of Ratisbon, that "They belonged to the Emperor, in order that he might preserve them from entire destruction at the hands of the Christians, and keep them as a memorial of the sufferings of Christ."

After the fourteenth century, this servitude to the exchequer came to be understood and applied as a complete slavery: "You belong," says the Emperor Charles IV, in a document addressed to the Jews, "to us and the empire with your lives and possessions; we can order, do, and act with these as we like and as seems good to us." In fact, the Jews frequently went, like an article of merchandise, from one hand into another; the Emperor declared, now here, now there, that their claims for the payment of debts were annulled, and caused a large sum of money, generally thirty per cent, to be paid by the debtors into his own treasury.

The protection which emperor and empire were supposed to accord to the servants of the exchequer was often illusory, even when they were granted special privileges; as a matter of fact, they were without civil rights. Only where self-interest dictated, not to allow men in so many ways useful and profitable to utterly perish, did the governments step in. Otherwise everybody's hand was against them, from emperor down through all ranks of society to the very rabble. Often protection was assured them only for a limited time, at the end of which they were as good as outlawed, unless they immediately bought with large sums of money a renewal of the letter of protection. They were used like sponges—allowed to completely fill themselves, in order to be then as completely squeezed out. What happened in the year 1390 deserves to be kept in the memory of Germans as a constant warning. King, princes, nobles, and cities were, by reason of long wars, all alike in debt; then the example that had been already given by France was copied. At the Imperial Diet held in Nuremberg, all money-claims by Jews were annulled, and, instead of paying their rightful creditors the debtors paid in fifteen per cent of their indebtedness to the royal treasury! In this way, for example, the Duke of Bavaria, the Count of Oettingen, and the city of Ratisbon, each won one hundred thousand gold florins.

If a prince ever showed a disposition to favor the Jews of his land

* The book containing the statute- and feudal-laws of South Germany.—TRANSLATOR.

or any single individual, by bestowing perhaps a piece of land or an office upon him, a papal letter soon appeared warning and threatening with punishment, and reminding the prince that a son of the handmaid should never be preferred to a son of the free-woman.* Cardinal legates of the Pope had it decided at councils (as at Vienna, in 1267) that no Jew should be permitted in a bath-house or drinking-saloon or an inn; that no Christian should dare buy meat of a Jew, since he might thus be treacherously poisoned. The Synod of Salamanca, of the year 1335, declared that physicians of the Mosaic faith offered their services only because they wished to destroy, as far as they could, the Christian people, and so, in effect, the population of all Europe.

In this way the seeds of hate and detestation were sown, and wholesale murder was the harvest. Accustomed to the view that every Jew is a born enemy and debtor to the Christians, the nations, in a time when what was cruel and unnatural was credulously laid hold of with a kind of predilection and even eagerness, held the Jews to be capable of every crime, even the most improbable and impossible. After the twelfth century, the story went about that the Jews craved Christian blood, some imagined for their festival of the passover, others as a remedy against a secret hereditary disease; and, to get it, that they put a boy to death every year. In addition, a pretense was made of knowing that they crucified a Christian every year in mockery of the Redeemer.

If a corpse, on which there were signs of violence, or a dead child, was found anywhere, a Jew must have been the murderer; generally, the crime was supposed to have been committed by a number jointly, and torture was continued till it extorted confessions. Then followed horrible executions, and in many cases a general butchering of the whole Jewish population in town and country. An orderly, unprejudiced judicial procedure was not to be thought of. The judges and magistrates trembled themselves before the rage of the populace, which had its mind made up from the start, and held fast to the presumption that the most infamous deeds might be expected of every member of this murderous people. Occasionally, it was an image of Christ, which a Jew was said to have pierced with a knife or mutilated, that gave the signal for a massacre. After the year 1290, rumors of maltreated and miraculously bleeding Hosts were added. From Paris, where the first case had happened, the news spread to the neighboring countries. Very soon the possession of a similar miraculous treasure was coveted elsewhere; and now it appeared as if the Jews, seized by a demoniacal frenzy, at once believed and disbelieved an ecclesiastical dogma, and had an irrepressible desire for an agonizing death—so frequently were these ostensible outrages revenged upon them.

In London the Jews were murdered because they were suspected

* *Cf.* Paul's Epistle to the Galatians, iv, 22–31.—(TRANSLATOR.)

of plotting to burn the great city with Greek fire. The great plague, which in 1348 swept over and depopulated all Europe, could only, it was easily known, proceed from the Jews. The fact that the sober and temperately living people were much less affected by the plague than the Christians, converted the bare suspicion into a certainty. They had everywhere, in consequence of a great conspiracy, in which the houses of lepers had also taken part, poisoned the springs and wells, and even the rivers. In Zofingen it was pretended that actual poison was found in one of the wells. On the rack some Jews and lepers confessed to the deed. There hence burst forth a storm of fanaticism, of bestial revenge and vulgar avarice, such as has never before nor since been seen in Europe. The victims were counted in single towns by thousands. Many anticipated the rage of the mob by taking their own lives. To no purpose did Pope Clement VI declare in two bulls that the Jews were innocent. Those who saved themselves by a swift flight found an asylum only in distant Lithuania.

Still, not merely on account of religion and the fictitious crime did the popular hatred direct itself against the Jews; there was in addition a third motive, acting just as, if not more strongly. The Jews loaned money on interest, they were usurers; they carried on an indeed indispensable but none the less sinful business, and fleeced, so the saying was, the Christians. The accusation was not untrue, and yet unjust.

Popes and councils, supporting themselves upon an incorrect interpretation of Luke vi, 35,* have since the end of the eighth century with one voice and with a continually increasing rigor, condemned and visited with ecclesiastical penalties all taking of interest, in whatever form, on loaned capital. In the early Church, only the clergy were forbidden to take interest; but, as the influence of the Papal chair increased, the prohibition was extended to the laity also.

No distinction was made between interest and usury, but every stipulation for or taking of the slightest amount over and above the capital that had been loaned was forbidden by the Popes and councils, a prohibition from which there could be (as Alexis III, in 1179, declared) in no case a dispensation. To this Clement V at the Council of Vienna added the decision that it is heresy to assert that the taking of interest is not a sin.

Unendurable fetters were thereby placed upon all commerce and business; and Pope Gregory IX declared even the money advances, with interest stipulated, which maritime traffic requires, to be damnable usury. The Church had thereby placed itself in contradiction with the nature of things, with the indispensable requirements of civil life and of general trade; she might, indeed, prevent her own members from taking interest, but she could not command or compel

* The revised translation reads, "and lend, never despairing," in place of the old translation, "and lend, hoping for nothing again."—(TRANSLATOR.)

them to loan out their money without interest. On account of the general lack of ready money in a time when the supply of gold and silver metal was continually decreasing, and a currency to take their place had not been devised, everybody from the highest to the lowest came very frequently to a pass where they must borrow money; and since trade in money was strictly forbidden to the Christians, and could only be carried on by them when veiled under other forms of business or in roundabout ways, the Jews, who were excluded from other branches of industry and positions in life, entered upon it. *An industrious people the Jews have ever been.* As long as they formed a state of their own, their principal occupations were agriculture, horticulture, and the trades. In their hands Palestine had become one of the best cultivated and most fruitful lands of the earth. The Mosaic legislation was intended to encourage the improvement of the soil, and to further the cultivation of grain, wine, and oil. Further, in the first centuries after Christ, and after the destruction of the Jewish state, the people remained faithful to their old customs. Josephus, in the beginning of the second century, still praises the industry of his countrymen in their trades and in agriculture.

There is no evidence to be found in the Roman literature and the laws of the emperors that the Jews had given themselves up to shrewd bargaining and small trading, or in general had become a commercial people. The numerous Jews that lived in Rome appear to have been poor. Further, the violent and extremely bloody risings of the Jews in Egypt and Cyrene, and on the islands (of the Mediterranean) indicate that they did not form a commercial population or one dealing in small wares, for such a class of people do not often take up arms. Even as late as the tenth century, they formed a stationary population in Spain, Southern France, and even in Germany. This condition, however, they could not maintain in face of the hostility of the Church and of the people, and moreover, after the rise of the Italian maritime and commercial cities with their merchant-fleets, they lost their hold upon the commerce between the West and the Orient. The concentration of trade in the guilds and the exclusion of the Jews from ordinary intercourse with Christians made it impossible for them to become artisans. Just as little could they live on agriculture, since they were almost everywhere forbidden to own land. Cardinal James, of Vitry, who knew the Orient well, observes in the year 1244, "Among the Mohammedans the Jews ply handicrafts, although it is only the lower and despised branches that they occupy themselves with, but among the Christians they live on the business of loaning money." The thought forces itself upon us, how great a benefit would have been conferred upon the world, Christian and Jewish alike, if a cardinal or a Pope at that time had reflected upon this contrast between the Jews under the Crescent and the Jews under the Cross, and had drawn from it the practical inferences that lie so near at hand.

In addition, the physician's calling was as a rule closed to the Jews, although in Mohammedan countries it was precisely as physicians that they won high distinction; for the councils forbade a sick person, on pain of excommunication, to take medicine from a Jewish physician—it being better, as they declared, to die than to be healed by an infidel? They were further excluded from all schools, high and low. Whoever had a desire for knowledge must become a rabbi, and if, as a very rare exception, a prince, like Alfonso X of Castile, made use of Jewish mathematicians and astronomers, the education of these men was obtained in lands where the Koran ruled. The taking of interest on loans from strangers was permitted to the Jews by their law, and the supposed prohibition by Christ was believed at first by both parties not to be binding upon the Jews. The matter changed, however, after Innocent III. At the end of the twelfth century, theologians and canonical writers taught that, in accordance with natural law as well as the divinely revealed law of the Old and New Testaments, the taking of interest in general is forbidden and is a sin. Innocent III ordered, therefore, that the Jews should be compelled to give back the interest they had collected, and to this end introduced an expedient that had not been used before, viz., that Christians should be compelled, on pain of excommunication, to break off all intercourse with those Jews who refused to make the returns. This amounted, in case the programme was strictly carried out, to delivering them over to death by starvation. Hence arose sad confusion and conflicts of many kinds. The bishops, whose duty it was to pronounce excommunication, were disposed often to execute their task in good earnest; and the synods (for example, that at Avignon in 1209) urged them to do so. The princes, on the other hand, in whose interest and as whose servants the Jews carried on their money-lending, protected them; or, on the other hand, as happened in not a few cases, confiscated their entire property for their own use, on the plea that it had been gained by taking interest. Sometimes they even compelled Christian debtors to pay the outstanding interest into their own treasury.

Interminable confusion to clergy and laity was the result of the action of the hierarchy in forbidding the taking of interest, and the canonical writers vexed themselves to invent distinctions and find ways of escape out of the labyrinth. In innumerable cases they found themselves helpless in face of the actual circumstances and practically abandoned the principle, although in theory no one could attack it on pain of death. In real consistency, the Christians should have been forbidden to borrow on interest, since by so doing they enticed the Jews to sin. But Popes, bishops, clergy, were themselves often in a situation in which they must seek for a loan and pay the interest; in fact, the whole organization of the curia, the management of the system of benefices, the taxation of the clergy by the Popes, were calculated to make bishops, clergy, monasteries, and chapters liable to the payment

of interest to Jewish capitalists. Under these circumstances the canonical writers finally decided that, being in any case lost, it was immaterial whether the Jews committed a few more or a few less sins; the borrowing Christians, however, were excused by their necessities.

The interest demanded by the Jews was, it is true, exceedingly high, and often beyond the power of the debtor to pay, but this was a result of the value of money at the time, of the scarcity of coin, and above all, of the oppressive amounts which the Jews were obliged to pay to princes and town authorities. The Caorsines and the great Italian bankers put their demands just as high as the Jews, and where they got the trade in money into their own hands the desire arose, as for example in Paris at the beginning of the fourteenth century, to have the Jews back again, since their activity as money-lenders was, on the whole, in many ways beneficial, and at that time irreplaceable. They did for the northern countries and for Spain what was done for Italy by the bankers' associations of the so-called Lombards, and by the money-brokers of Asti, Sienna, Florence, and other cities, who were partly patronized and partly silently tolerated (and in either case frequently called into requisition) by the Popes and bishops. In France and England there was even at times competition between Lombard and Jew. The Emperor Louis's son, Louis the Brandenburger, issued in the year 1352 a public invitation to the Jews to settle free of taxation in his land, because "since the time when the Jews were destroyed (referring to the great massacre of 1348), there has been everywhere, both among rich and poor, a deficiency in ready money."

CHEMISTRY IN HIGH-SCHOOLS.

By ELISA A. BOWEN.

I HAVE, for some years, been trying to improve the teaching of chemistry in girls' schools. It is, of course, work of the most elementary character. I wished earnestly to make it, so far as it went, inductive study—in other words, to train the observing powers to select for themselves the significant facts; and to train the reasoning powers to draw for themselves, with some degree of independence, the more important of the general principles which we call the theory of chemistry.

When I began to teach this subject, about six years ago, the progressive teachers had become dissatisfied with the old plan of book-study or lecture, with experiments by the teacher. The best thing offered as improvement was the performance of experiments by the pupils themselves. This was certainly an important advance; and manipulation is, first or last, essential to any complete knowledge of

chemistry. But it is not all that is needed. *Mental* activity is the important thing.

I will illustrate the plan which has proved best in my own experience, merely saying, first, that even where pupils have studied physics, I have a preliminary drill to make sure the girls are quite clear about the forms of matter, the properties of liquids and gases, attractive and repulsive forces. I do not say a word to them about *chemical* attraction, because I wish them to study that out for themselves. Sometimes they have already learned by heart a definition from some book on physics; but, as Thomas Carlyle would say, "by the blessing of Heaven they have generally forgotten it."

I think the best experiment to begin with is the evolution of oxygen gas by heating the red oxide of mercury. This is not the easiest or the most convenient way of obtaining oxygen, but it is much the simplest process.* I do not usually tell my pupils anything—not even what the substance is which they are to make; but they know I shall question them closely about what they have seen. When the experiment is concluded—the gas tested with a glowing taper; the residue of mercury examined; and a little of the red oxide put into water and stirred, to show that it will not dissolve—I usually ask questions about as follows:

"When the jar was lifted from the water to the shelf, why did not the water fall out? Why did the water afterward sink in the jar? Did you see anything in the jar as the water fell? Why do you think there was anything in the upper part of the jar? What form of matter was it? How do you know that it was not air? How was it like air? How was it unlike air? Had it color or smell? Did it burn? What was it burned? Did the gas have anything to do with the burning?" † I then tell them the gas is called oxygen; and I write on my blackboard the name and symbol, with a list of the properties which they have just discovered.

I then proceed to ask: "What remained in the ignition tube at the close of the experiment? What form of matter was it? Did you ever before see anything with that shiny luster? What class of bodies have it?" Then I tell those who do not already know that it is mercury, and I give the symbol, Hg.

I then say: "Where were the gas and the liquid when that red powder was placed in the tube? What became of the powder? Did it take any force to separate the gas and liquid which you say formed the powder? What was the force? What sort of a force is heat? Do you suppose any force held the oxygen and mercury together? Do you know a general name given to forces which unite

* I always, of course, have ready a quantity previously otherwise made.

† I find that pupils will at first, of themselves, make the somewhat conventional distinction between "combustibles" and "supporters of combustion." For a while I let this pass.

bodies? Name some kinds of attraction. Is this force cohesion? Why not? Is it adhesion? Why not?" I finally tell them the force is called *chemical attraction*, and I call on them to put into words a clear definition of chemical attraction. As they do so, I simply criticise the successive trials they make, until the definition is correct in matter and form; and then, after making them repeat it several times in concert, I write it on the blackboard.

By similar questions, which I will not weary the reader by repeating, I make them draw from the same experiment facts and definitions about elements, simple substances, compounds, oxides, decomposition, etc., etc.

In my life, I have taught a great deal of Latin and English, but I know no such language-lesson as is given when a class, under the fire of a skillful teacher's criticism, slowly perfects a clear logical statement, or definition, for which they have gained the material by using their own senses and reason. My pupils keep note-books, and at every lesson bring me, neatly written out, the substance of the previous lesson.

I have given above only a sample of the general tenor of questions. Sometimes some misapprehension on the part of pupils makes me diverge widely to bring them back on the track.

I endeavor to make the subject as practical as possible by having pupils study the chemistry of common operations. After the above experiment, I usually introduce the subject of *air* by asking: "Why did the taper at last fail to light again when dipped into the jar? What had become of the oxygen in the jar? Did the remains of the burned paper look like the remains when paper is burned in the air?"

After this I take a bit of sodium and burn it in oxygen. I also oxidize some in the air. I show, by testing, that the oxygen has disappeared from the jar. I test the first oxide with red litmus, both before and after dissolving in water. I let the pupils taste a little of a very dilute solution. I then ask questions about sodium just as I did about oxygen and mercury. I ask what has become of the oxygen and the sodium; what unites them; what the force is called; draw them on to classify the result of the union as a compound and an oxide; draw them on to note the properties of the compound. Then I have them test the oxide formed in the air just as the other was tested. I ask: "Is this a compound? Do you think you know either of its elements? Of which one are you sure? Do you think you know the other element? Why do you think it is oxygen? Where did the oxygen come from? What other reason have you for thinking the air contains oxygen?"

I wait for further experiments before indorsing their partly formed conclusion about oxygen in the air. We next make some study of carbon by burning coal in oxygen. I have them test the result with lime-water. We burn coal in a receiver of air, and test this result also. I have some powdered charcoal heated in contact with the red oxide

of mercury, and that result tested. Every particle of information which observation can draw from these experiments is carefully elicited by questions such as I have described.

At this point I usually inform them that the red oxide of mercury is sometimes made by heating mercury a long time in contact with air. They commonly by this time consider the evidence of oxygen in the air pretty conclusive. I next lead them to think about the air we breathe: whether it comes from our lungs unchanged; to think of some way of testing whether it contains free oxygen. I have them test the breath with lime-water, discuss the effect of the union of carbon and oxygen, especially the heat.

In all this I tell them very little. I become greatly interested in seeing how much I can get them to do for themselves. I simply try to stimulate and get them on the right track. At this point I usually ask them whether they think the air contains anything besides oxygen, and set them to discussing ways of getting at the other element in air.

Devising experiments is a very important part of chemical training, and, where the pupil sees beforehand some question to settle, he can be made to do it. By rousing him to think, criticising his crude plan, and showing, or making him think of, its defects, it can be done. Pupils will devise the well-known experiment of burning away oxygen from air, but of course they must be told that phosphorus is the best combustible for their purpose. By taking up the various requirements of the experiment separately, they will suggest nearly everything.

But before the experiment is actually carried out, to prevent the confusion which would arise from the vapor of phosphoric anhydride, I have them make a little study of phosphorus. It is examined, burned in oxygen, burned in air, the anhydride noted, its great affinity for water, its behavior to litmus both before and after union with water, its taste noted, etc. After this we use phosphorus to help us study the composition of air. The girls note (approximately) the proportion of oxygen to nitrogen.

We test the air for carbonic acid; discuss the moisture in it, etc.; and then I have them make some study of water. To do this I first put a bit of sodium in a very small cage of wire gauze, and thrust it under a little water. The result is tested, and shown to be the same compound they before knew. When they are satisfied that the oxygen must come from the water, we collect hydrogen and examine it. I have them also note the new method of decomposition. Then we have the proof by synthesis, burning hydrogen and collecting a little of the water.

As we proceed, my pupils begin to think ahead of questions, and their perceptions grow sharper.*

* In final review, I employ the topical method of recitation, but this method is too loose for *investigation*, which must be held down to accuracy, by well-considered questions, taking up one point at a time.

If, after this, we decompose water by a battery, the students will at once recognize the process for themselves as decomposition; and it confirms their previous analysis of water. But, if I begin experimenting by battery decomposition, they can not study out for themselves the rationale of the process. Of course, the teacher can explain and point out and make it understood, but they take it all pretty much upon authority, and their minds are far less active and independent. And so, of making oxygen at first with potassium chlorate. The chlorate is a less simple substance than the red oxide of mercury; and the presence of the binoxide of manganese, with the catalysis, complicates the process.

While directing this experimental study I do not tell them any of the facts which come on testimony, unless, like the fact about the making of the red oxide of mercury, it is a necessary step in some chain of reasoning which they can make out mainly for themselves.

The precautions necessary in using such substances as sodium make it unwise and imprudent to set careless young folks to handling them. One accident would bring lasting disrepute on our chemical study.

Showy experiments are demoralizing, though they excite for the time a sensational interest. But, when young folks really think for themselves, they are so pleased with it that they can take the highest interest in a very simple process. There is an experiment which I learned from that capital book, "Eliot and Storer's Chemistry," which illustrates a good many things I have said. It is designed to show the great diffusibility of hydrogen. A tube, closed at one end with plaster of Paris, is filled with hydrogen, and put in a tumbler of water for a day or two. The water first rises in the tube, then sinks to the level of that in the tumbler, in consequence of hydrogen escaping faster than air comes in. When I first taught chemistry, my pupils took no interest in this experiment. When I tried making them discuss the changes, and discover for themselves the property of hydrogen which causes them (which they do with all ease), they find it more interesting than the burning of phosphorus in oxygen. This experiment shows, too, how genuine inductive teaching must necessarily be oral teaching, for a text-book merely *tells* the philosophy of the changes, which is precisely the thing the pupils ought not to be told.

When chemistry is taught inductively, the order in which the subject is presented becomes important. It is of the highest consequence that the more dependent parts of the science should not be put forward in the beginning. I do not think the order of our American text-books so good as that of Stockhardt.

I will state, in a very few words, the order which seems to me best. I usually make the pupil study, first, the individual properties of the thirty chief elements, taking up no compounds but oxides and hydrogen acids. The pupil should test the oxides with red or blue litmus; note the acid or basic taste; note which are insoluble in water. The

difference between hydrates and anhydrides should be clearly brought out, and the part which hydrogen plays. After this survey, the pupil, for himself, without prompting, divides the elements into their two great classes.

Then, after some little study of sulphides and the other binary compounds, the principal acids and bases should be shown in their concentrated form. After this, a number of them should be combined to form salts, and, in doing this, it should be brought out very clearly (*by*, not *for* the pupil) how the bases replace the hydrogen of the acid. There should also be some general study of crystallization.

It would be easy to multiply suggestions, but it has been my purpose in this brief paper simply to describe what I have tried, and give only the results of experience.

A NEW THEORY OF THE SUN.

THE CONSERVATION OF SOLAR ENERGY.

By C. WILLIAM SIEMENS.

A PAPER was recently read by me before the Royal Society, under the above title, which may be termed a first attempt to open for the sun a creditor and debtor account, inasmuch as he has hitherto been regarded only as the great almoner, pouring forth incessantly his boundless wealth of heat, without receiving any of it back. Such a proposal touches the root of solar physics, and can not therefore be expected to pass without challenge—to meet which I gladly embrace the opportunity, now offered to me through the courtesy of the editor of this review, of enlarging somewhat upon the first concise statement of my views regarding this question.

Man has from the very earliest ages looked up with a feeling of awe and wonderment to our great luminary, to whom we owe not only the light of day, but the genial warmth by which we live, by which our hills are clad with verdure, our rivers flow, and without which our life-sustaining food, both vegetable and animal, could not be produced.

When for our comfort and our use we resort to a fire either of wood or coal, we know now by the light of modern science that we are utilizing only solar rays that have been stored up by the aid of the process of vegetation in our forests or in the forests of former geological ages, when our coal-fields were the scenes of rank tropical growth. The potency of the solar ray in this respect was recognized—even before science had discovered its true significance—by clear-sighted men such as the late George Stephenson, who, when asked what in his opin-

ion was the ultimate cause of the motion of his locomotive-engine, said that he thought it went by "the bottled-up rays of the sun."

With the exception of our coal-fields and a few elementary combustible substances such as sulphur and what are called the precious metals, which we find sparsely scattered about, our earth consists essentially of combined matter. Thus our rivers, lakes, and oceans are filled with oxidized hydrogen, the result of a most powerful combustion; and the crust of our earth is found to consist either of quartz (a combination of the metal silicon with oxygen) or limestone (oxidized calcium combined with oxidized carbon), or of other metals, such as magnesium, aluminium, or iron, oxidized and combined in a similar manner. Excepting, therefore, the few substances before enumerated, we may look upon our earth, near its surface at any rate, as a huge ball of cinder, which, if left to itself, would soon become intensely cold, and devoid of life or animation of any kind.

It is true that a goodly store of heat still exists in the interior of our earth, which, according to some geologists, is in a state of fusion, and must certainly be in a highly heated condition; but this internal heat would be of no avail, owing to the slow rate of conduction, by which alone, excepting volcanic action, it could be brought to us living upon its surface.

An estimate of the amount of heat poured down annually upon the surface of our earth may be formed from the fact that it exceeds a million times the heat producible by all the coal raised, which may be taken at 280,000,000 tons a year.

If, then, we depend upon solar radiation for our very existence from day to day, it can not be said that we are only remotely interested in solar physics, and the question whether and how solar energy, comprising the rays of heat, of light, and the actinic rays, is likely to be maintained, is one in which we have at least as great a reversionary interest as we have in landed estate or other property.

If the amount of heat, or, more correctly speaking, of energy, supplied annually to our earth is great as compared with terrestrial quantities, that scattered abroad in all directions by the sun strikes us as something almost beyond conception.

The amount of heat radiated from the sun has been approximately computed by the aid of the pyrheliometer of Pouillet, and by the actinometers of Herschel, at 18,000,000 heat-units from every square foot of its surface per hour; or, expressed popularly, if coal were consumed on the surface of the sun in the most perfect manner, our total annual production of 280,000,000 tons, being the estimated produce of all the coal-mines of the earth, would suffice to keep up solar radiation for only one forty-millionth part of a second; or, if the earth were a mass of coal, and could be supplied by contract to the solar furnace-men, this supply would last them just thirty-six hours.

If the sun were surrounded by a solid sphere of a radius equal to

the mean distance of the sun from the earth (95,000,000 miles), the whole of this prodigious amount of heat would be intercepted; but considering that the earth's apparent diameter as seen from the sun is only seventeen seconds, the earth can intercept only the 2,250-millionth part. Assuming that the other planetary bodies swell the amount of intercepted heat to ten times this amount, there remains the important fact that $\frac{224999999}{225000000}$ of the solar energy is radiated into space, and apparently lost to the solar system, and only $\frac{1}{2250000000}$ utilized or intercepted.

Notwithstanding this enormous loss of heat, solar temperature has not diminished sensibly for centuries, if we neglect the periodic changes, apparently connected with the appearance of sun-spots, that have been observed by Lockyer and others, and the question forces itself upon us, how this great loss can be sustained without producing an observable diminution of solar temperature, even within a human life-time.

Among the ingenious hypotheses intended to account for a continuance of solar heat is that of shrinkage or gradual reduction of the sun's volume, suggested by Helmholtz. It may, however, be argued against this theory that the heat so produced would be liberated throughout its mass, and would have to be brought to the surface by conduction, aided perhaps by convection; but we know of no material of sufficient conductivity to transmit anything approaching the amount of heat lost by radiation.

Chemical action between the constituent parts of the sun has also been suggested; but here again we are met by the difficulty that the products of such combination would, ere this, have accumulated on the surface, and would have formed a barrier against further action.

These difficulties led Sir William Thomson to the suggestion that the cause of maintenance of solar temperature might be found in the circumstance of meteorites, not falling upon the sun from great distances in space, as had been suggested by Mayer and Waterton, but circulating with an acquired velocity within the planetary distances of the sun, and he shows that each pound of matter so imported would represent a large number of heat-units, without disturbing the planetary equilibrium. But in considering more fully the enormous amount of planetary matter that would be required for the maintenance of the solar temperature, Sir William Thomson soon abandoned this hypothesis for that of simple transfer of heat from the interior of a fluid sun to the surface by means of convection-currents, which latter hypothesis is at the present time supported by Professor Stokes and other leading physicists.

This theory has certainly the advantage of accounting for the greatest possible store of heat within the solar mass, because it supposes the latter to consist in the main of a fluid heated to such a temperature that, if it were relieved at any point of the confining pressure,

it would flash into gas of a vastly inferior, but still of an elevated, temperature. It is supposed that such fluid material, or material in the "critical" condition, as Professor Thomas Andrews, of Belfast, has named it, is continually transferred to the surface by means of convection-currents, that is to say, by currents forming naturally when a fluid substance is cooled at its upper surface, and sinks down after cooling to make room for ascending material at the comparatively higher temperature. It is owing to such convection-currents that the temperature of a room is, generally speaking, higher toward the ceiling than toward the floor, and that upon plunging a thermometer into a tank of heated water the surface temperature is found slightly superior to that near the bottom.

These convection-currents owe their existence to a preponderance of the cooled descending over the ascending current; but this difference being slight, and the ascending and descending currents intermixing freely, they are, generally speaking, of a sluggish character; hence, in all heating apparatus, it is found essential to resort either to artificial propulsion, or to separating walls between the ascending and the descending currents, in order to give effect to the convective transfer of heat.

In the case of a fluid sun another difficulty presents itself through the circumstance that the vast liquid interior is enveloped in a gaseous atmosphere, which, although perhaps some thousands of miles in depth, represents a relatively very small store of heat. Convection-currents may be supposed active in both the gaseous atmosphere and in the fluid ocean below, but the surface of this fluid must necessarily constitute a barrier between the two convective systems, nor could the convective action of the gaseous atmosphere—that is to say, the simple up and down currents caused by surface refrigeration—be such as to disturb the liquid surface below to any great extent, because each descending current would have had plenty of time to get intermixed with its neighboring ascending current, and would, therefore, have reached its least intensity on arriving on the liquid surface.

As regards the liquid, its most favorable condition for heating purposes would be at the critical point, or that at which the slightest diminution of superincumbent pressure would make it flash off into gas; but considering that, by means of conduction and convection, the liquid matter must have assumed, in the course of ages, a practically uniform temperature to a very considerable depth, it follows that the liquid below the surface, with fluid pressure in addition to that of the superimposed gaseous atmosphere, must be ordinary fluid, the critical condition being essentially confined only to the surface.

Conditions analogous to those here contemplated are met with in a high-pressure steam-boiler, with its heated water and dense vapor atmosphere. Suppose the fire below such a boiler be withdrawn, and its roof be exposed to active radiation into space, what should we ob-

serve through a strong pane of glass inserted in the side of the boiler near the liquid surface, lit up by an incandescent electric lamp within? The loss of heat by radiation from the boiler would give rise to convection-currents, and partial condensation of the vapor atmosphere; then, if the motion of the water were made visible by means of coloring matter, we should observe convection-currents in the fluid mass separate and distinct from those in the gaseous mass; but these convection-currents would cause no visible disturbance of the liquid surface, which would present itself to the eye with the smoothness of a mirror. It is only in the event of the steam-pressure being suddenly relieved at any point on the surface that a portion of the water would flash into steam, causing a violent upheaval of the liquid.

The dark spots on the sun appear to indicate commotion of this description, but these are evidently not the result of mere convection-currents; if they were, they would occur indiscriminately over the entire surface of the sun, whereas telescopic observation has revealed the fact that they do occur almost exclusively in two belts, between the equator and the polar surfaces on either side. Their occurrence could be satisfactorily explained if we could suppose the existence of strong lateral currents flowing from the polar surfaces toward the equator, which lateral currents in the solar atmosphere would cause cyclones or vortex action with a lower and denser atmosphere consisting probably of metallic vapors; this vortex action extending downward would relieve the fluid ocean locally from pressure, and give rise to explosive outbursts of enormous magnitude, projecting the lower atmosphere high above the photosphere, with a velocity measured, according to Lockyer, by a thousand miles a second. It will be seen from what follows how, according to my views, such vortex action in those intermediate regions of the sun would necessarily be produced.

But supposing that, notwithstanding the difficulties just pointed out, convection-currrents sufficed to effect a transfer of internal heat to the surface with sufficient rapidity to account for the enormous surface-loss by radiation, we should only have the poor satisfaction of knowing that the available store would last longer than might have been expected, whereas a complete solution of the problem would be furnished by a theory, according to which the radiant energy which is now supposed to be dissipated into space and irrecoverably lost to our solar system, could be arrested and brought back in another form to the sun himself, there to continue the work of solar radiation.

Some six years ago the thought occurred to me that such a solution of the solar problem might not lie beyond the bounds of possibility, and, although I can not claim intimate acquaintance with the intricacies of solar physics, I have watched its progress, and have engaged also in some physical experiments bearing upon the question, all of which have served to strengthen my confidence, and to ripen in me

the determination to submit my views, not without some misgiving, to the touchstone of scientific criticism.

For the purposes of my theory, stellar space is supposed to be filled with highly rarefied gaseous bodies, including hydrogen, oxygen, nitrogen, carbon, and their compounds, besides solid materials in the form of dust. Each planetary body would in that case attract to itself an atmosphere depending for density upon its relative attractive importance, and it would not seem unreasonable to suppose that the heavier and less diffusible gases would form the staple of these local atmospheres; that, in fact, they would consist mostly of nitrogen, oxygen, and carbonic acid, while hydrogen and its compounds would predominate in space.

In support of this view it may be urged that, in following out the molecular theory of gases as laid down by Clausius, Clerk Maxwell, and Thomson, it would be difficult to assign a limit to a gaseous atmosphere in space; and, further, that some writers—among whom I will here mention only Grove, Humboldt, Zöllner, and Mattieu Williams—have boldly asserted the existence of a space filled with matter. But Newton himself, as Dr. Sterry Hunt tells us in an interesting paper which has only just reached me, has expressed views in favor of such an assumption.

The history of Newton's paper is remarkable and very suggestive. It was read before the Royal Society on the 9th and 16th of December, 1675, and remained unpublished until 1757, when it was printed by Birch, the then secretary, in the third volume of his "History of the Royal Society," but received no attention; in 1846 it was published in the "Philosophical Magazine" at the suggestion of Harcourt, but was again disregarded; and now, once more, only a few months since, a philosopher on the other side of the Atlantic brings back to the birthplace of Newton his forgotten and almost despised work of two hundred years ago.

Quoting from Dr. Sterry Hunt's paper:

Newton in his Hypothesis imagines "an ethereal medium much of the same constitution with air, but far rarer, subtler, and more elastic. . . . But it is not to be supposed that this medium is one uniform matter, but composed partly of the main phlegmatic body of ether, partly of other various ethereal spirits, much after the manner that air is compounded of the phlegmatic body of air intermixed with various vapors and exhalations." Newton further suggests in his Hypothesis that this complex spirit or ether, which, by its elasticity, is extended throughout all space, is in continual movement and interchange. "For Nature is a perpetual circulatory worker, generating fluids out of solids, and solids out fluids; fixed things out of volatile, and volatile out of fixed; subtile out of gross, and gross out of subtile; some things to ascend and make the upper terrestrial juices, rivers, and the atmosphere, and by consequence others to descend for a requital to the former. And as the earth, so perhaps may the sun imbibe this spirit copiously, to conserve his shining, and keep the planets from receding further from him; and they that will may also suppose that this spirit affords or

carries with it thither the solary fuel and material principle of life, and that the vast ethereal spaces between us and the stars are for a sufficient repository for this food of the sun and planets. . . . Thus, perhaps, may all things be originated from ether."

If at the time of Newton chemistry had been understood as it now is, and if, moreover, he had been armed with that most wonderful of all modern scientific instruments, the spectroscope, the direct outcome of his own prismatic analysis, there appears to be no doubt that the author of the laws of gravitation would have so developed his thoughts upon solar fuel that they would have taken the form rather of a scientific discovery than of a mere speculation.

Our proof that interstellar space is filled with attenuated matter does not rest, however, solely upon the uncertain ground of speculation. We receive occasionally upon our earth celestial visitors termed meteorites; these are known to travel in loose masses round the sun in orbits intersecting at certain points that of our earth. When in their transit they pass through the denser portion of our atmosphere they become incandescent, and are popularly known as falling stars. In some cases they are really deserving of that name, because they strike down upon our earth, from the surface of which they have been picked up and subjected to searching examination while still warm after their exertion. Dr. Flight has only very recently communicated to the Royal Society an analysis of the occluded gases of one of these meteorites as follows:

CO_2 (Carbonic acid)	0·12
CO (Carbonic oxide)	31·88
H (Hydrogen)	45·79
CH_4 (Marsh-gas)	4·55
N (Nitrogen)	17·66
	100·00

It appears surprising that there was no aqueous vapor, considering that there was much hydrogen and oxygen in combination with carbon; but perhaps the vapor escaped observation, or was expelled to a greater extent than the other gases by external heat when the meteorite passed through our atmosphere. Opinions concur that the gases found occluded in meteorites can not be supposed to have entered into their composition during the very short period of traversing our denser atmosphere; but, if any doubt should exist on this head, it ought to be set at rest by the fact that the gas principally occluded is hydrogen, which is not contained in our atmosphere in any appreciable quantity.

Further proof of the fact that stellar space is filled with gaseous matter is furnished by spectrum analysis, and it appears from recent investigation, by Dr. Huggins and others, that the nucleus of a comet contains very much the same gases found occluded in meteorites, in-

cluding "carbon, hydrogen, nitrogen, and probably oxygen," while, according to the views set forth by Dewar and Liveing, it also contains nitrogenous compounds such as cyanogen.

Adversely to the assumption that interplanetary space is filled with gases, it is urged that the presence of ordinary matter would cause sensible retardation of planetary motion, such as must have made itself felt before this; but, assuming that the matter filling space is an almost perfect fluid not limited by border surfaces, it can be shown on purely mechanical grounds that the retardation by friction through such an attenuated medium would be very slight indeed, even at planetary velocities.

But it may be contended that, if the views here advocated regarding the distribution of gases were true, the sun should draw to himself the bulk of the least diffusible, and therefore the heaviest gases, such as carbonic acid, carbonic oxide, oxygen, and nitrogen, whereas spectrum analysis has proved, on the contrary, a great prevalence of hydrogen.

In explanation of this seeming anomaly, it can be shown, in the first place, that the temperature of the sun is so high that such compound gases as carbonic acid and carbonic oxide could not exist within him, their point of dissociation being very much below the solar temperature. It has been contended, indeed, by Mr. Lockyer, that none of the metalloids have any existence at these temperatures, although as regards oxygen Dr. Draper asserts its existence in the solar photosphere. There must be regions, however, outside that thermal limit, where their existence would not be jeopardized by heat; and here great accumulation of the comparatively heavy gases that constitute our atmosphere would probably take place, were it not for a certain counterbalancing action.

I here approach a point of primary importance in my argument, upon the proof of which my further conclusions must depend.

The sun completes one revolution on its axis in twenty-five days, and its diameter being taken at 882,000 miles, it follows that the tangential velocity amounts to 1·25 miles per second, or to what the tangential velocity of our earth would be if it occupied five hours instead of twenty-four in accomplishing one revolution. This high rotative velocity of the sun must cause an equatorial rise of the solar atmosphere, to which Mairan, in 1731, attributed the appearance of zodiacal light. Laplace rejected this explanation on the ground that zodiacal light extended to a distance from the sun exceeding our own, whereas the equatorial rise of the solar atmosphere due to its rotation could not exceed nine twentieths of the distance of Mercury. But it must be remembered that Laplace based his calculation upon the generally accepted hypothesis of an empty stellar space (occupied only by an imaginary ether), and it can be shown that the result of solar rotation would be widely different, if supposed to take place

within a medium of unbounded extension. In this case pressures would be balanced all round, and the sun would act mechanically upon the floating matter surrounding him in the manner of a fan, drawing it toward himself upon the polar surfaces, and projecting it outward in a continuous disk-like stream from the equatorial surfaces.

By this fan action, hydrogen, hydrocarbons, and oxygen are supposed to be drawn in enormous quantities toward the polar surfaces of the sun ; during their gradual approach they pass from their condition of extreme attenuation and intense cold to that of compression, accompanied with increase of temperature, until, on approaching the photosphere, they burst into flame, giving rise to a great development of heat, and a temperature commensurate with their point of dissociation at the solar density. The result of their combustion will be aqueous vapor and carbonic acid, and these products of combustion, in yielding to the influence of centrifugal force, will flow toward the solar equator, and be thence projected into space.

In view of the importance of this centrifugal action for the purpose of my theory, the following simple mathematical statement of the problem may not be thought out of place : Let us consider the condition of two equal gaseous masses, at equal distances from the solar center, the one in the direction of the equator, the other in that of either of the poles. These two masses would be equally attracted toward the sun, and balance one another as regards the force of gravitation, but the former would be subject to another force, that of centrifugal action, which, however small in amount as compared with the enormous attraction of the sun, would destroy the balance, and determine a motion toward the sun as regards the mass opposite the polar surface, and into space as regards the equatorial mass. The same action would take effect upon the masses filling their places, and the result must be a continuous current depending for its velocity upon the rate of solar rotation. The equatorial current so produced, owing to its mighty proportions, would flow outward into space, to a practically unlimited distance.

The next question for consideration is, What would become of these products of combustion when thus returned into space? Apparently they would gradually change the condition of stellar material, rendering it more and more neutral ; but I venture to suggest the possibility, nay, the probability, that solar radiation will, under these conditions, step in to bring back the combined materials to a state of separation by dissociation carried into effect at the expense of that solar energy which is now supposed to be irrevocably lost or dissipated into space as the phrase goes.

According to the law of dissociation as developed by Bunsen and Sainte-Claire Deville, the point of decomposition of different compounds depends upon the temperature on the one hand, and upon the pressure on the other. According to Sainte-Claire Deville, the disso-

ciation tension of aqueous vapor at atmospheric pressure and at 2,800° C. is 0·5, that is to say one half of the vapor would exist as such, the remaining half being found as a mechanical mixture of hydrogen and oxygen; but, with the pressure, the temperature of dissociation rises and falls, as the temperature of saturated steam rises and falls with its pressure. It is therefore conceivable that the solar photosphere may be raised by combustion to a temperature exceeding 2,800° C., whereas dissociation may be effected in space at a lower temperature. This temperature of 2,800° would be quite sufficient to account for the character and amount of solar radiation, if it is only borne in mind that the luminous atmosphere may be a thousand miles in depth, and that the flame of hydrogen and hydrocarbons, in the uppermost layers of this zone, is transparent to the radiant energy produced in the layers below, thus making the total radiation rather the sum of matter in combustion than the effect of a very intensely heated surface.

Sainte-Claire Deville's investigations had reference only to heats measured by means of pyrometers, but do not extend to the effects of radiant heat. Dr. Tyndall has shown by his important researches that vapor of water and other gaseous compounds intercept radiant heat in a most remarkable degree, and there is other evidence to show that radiant energy from a source of high intensity possesses a dissociating power far surpassing the measurable temperature to which the compound substance under its influence is raised. Thus carbonic acid and water are dissociated in the leaf-cells of plants under the influence of the direct solar ray at ordinary summer temperature, and experiments in which I have been engaged for nearly three years * go to prove that this dissociating action is obtained also under the radiant influence of the electric arc, although it is scarcely perceptible if the energy is such as can be produced by an inferior source of heat.

The point of dissociation of aqueous vapor and carbonic acid admits, however, of being determined by direct experiment. It engaged my attention some years ago, but I have hesitated to publish the qualitative results I then obtained, in the hope of attaining to quantitative proofs.

These experiments consisted in the employment of glass tubes furnished with platinum electrodes, and filled with aqueous vapor or with carbonic acid in the usual manner, the latter being furnished with caustic soda to regulate the vapor-pressure by heating. Upon immersing one end of the tube charged with aqueous vapor in a refrigerating mixture of ice and chloride of calcium, its temperature at that end was reduced to −32° C., corresponding to a vapor-pressure, according to Regnault, of $\frac{1}{1800}$ of an atmosphere. When so cooled no slow electric discharge took place on connecting the two electrodes with a small

* See "Proceedings, Royal Society," vol. xxx, March 1, 1880; also a paper read before Section A of the British Association, September 1, 1881, and ordered to be printed in the report.

induction-coil. I then exposed the end of the tube projecting out of the freezing mixture, backed by white paper, to solar radiation (on a clear summer's day) for several hours, when, upon again connecting up to the inductorium, a discharge, apparently that of a hydrogen vacuum, was obtained. This experiment being repeated furnished unmistakable evidence, I thought, that aqueous vapor had been dissociated by exposure to solar radiation. The carbonic-acid tubes gave, however, less unmistakable effects. Not satisfied with these qualitative results, I made arrangements to collect the permanent gases so produced by means of a Sprengel pump, but was prevented by lack of time from pursuing the inquiry, which I propose, however, to resume shortly, being of opinion that, independently of my present speculation, the experiments may prove useful in extending our knowledge regarding the laws of dissociation.

It should be here observed that, according to Professor Stokes, the ultra-violet rays are in large measure absorbed in passing through clear glass, and it follows from this discovery that only a small portion of the chemical rays found their way through the tubes to accomplish the work of dissociation. This circumstance being adverse to the experiment only serves to increase the value of the effect observed, while it appears to furnish additional proof of the fact, first enunciated by Professor Draper, and corroborated by my own experiments on plants, that the dissociating power of light is not confined to the ultra-violet rays, but depends in the process of vegetation chiefly upon the yellow and red rays.

Assuming, for my present purpose, that dissociation of aqueous vapor was really effected in the experiment just described, and assuming, further, that stellar space is filled with aqueous and other vapor of a density not exceeding the $\frac{1}{2000}$ part of our atmosphere, it seems reasonable to suppose that its dissociation would be effected by solar radiation, and that solar energy would thus be utilized. The conjoint presence of aqueous vapor, carbonic acid, and nitrogen would only serve to facilitate their decomposition, in consequence of the simultaneous formation of hydrocarbons and nitrogenous compounds by combination of the nascent hydrogen and the nitrogen with carbon in a manner analogous to what occurs in vegetation. It is not necessary to suppose that all the energy radiated from the sun into space should be intercepted, inasmuch as even a partial return of heat in the manner described would serve to supplement solar radiation, the balance being made up by absolute loss. To this loss of energy would have to be added that consumed in sustaining the circulating current, which however, need not relatively be more than what is known to be lost on our earth through the tidal action, and may be supposed to be compensated as regards the time of solar rotation by gradual shrinkage.

By means of the fan-like action resulting from the rotation of the sun, the vapors dissociated in space to-day would be drawn toward the

polar surfaces of the sun to-morrow, be heated by increase in density, and would burst into flame at a point where both their density and temperature had reached the necessary elevation to induce combustion, each complete cycle taking, however, years to be accomplished. The resulting aqueous vapor, carbonic acid, and carbonic oxide would be drawn toward the equatorial regions, and be then again projected into space by centrifugal force.

Space would, according to these views, be filled with gaseous compounds in process of decomposition by solar radiant energy, and the existence of these gases would furnish an explanation of the solar absorption spectrum, in which the lines of some of the substances may be entirely neutralized and lost to observation. As regards the heavy metallic vapors revealed in the sun by the spectroscope, it is assumed that these form a lower and denser solar atmosphere, not participating in the fan-like action which is supposed to affect the light outer atmosphere only, in which hydrogen is the principal factor.

Such a dense metallic atmosphere could not participate in the fan action affecting the lighter photosphere, because this is only feasible on the supposition that the density of the inflowing current is, at equal distances from the gravitating center, equal or nearly equal to the outflowing current. It is true that the products of combustion of hydrogen and hydrocarbon are denser than their constituents, but this difference may be balanced by their superior temperature on leaving the sun, whereas the metallic vapors would be unbalanced, and would therefore obey the laws of gravitation, recalling them to the sun. On the surface of contact between the two solar atmospheres, intermixture induced by friction must take place, however, giving rise to those vortices and explosive effects within the zones of the sun, between the equator and the polar surfaces, to which reference has already been made in this article; these may appropriately be called the "stormy regions" of the sun, which were first observed and commented upon by Sir John Herschel. Some of the denser vapors would probably get intermixed, be carried away mechanically by the lighter gases, and give rise to that cosmic dust observed to fall upon our earth in not inappreciable quantities, and generally assumed hitherto to be the *débris* of broken meteorolites. Excessive intermixture between the heat-producing atmosphere and the metallic vapors below appears to be prevented by the existence of an intermediate neutral atmosphere, and called the penumbra.

As the whole solar system moves through space at a pace estimated at 150,000,000 miles annually (being about one fourth of the velocity of the earth in its orbit), it appears possible that the condition of the gaseous fuel supplying the sun may vary according to its state of previous decomposition, in which other heavenly bodies may have taken part, and whereby an interesting reflex action between our sun and other heavenly bodies would be brought about. May it not be

owing to such differences in the quality of the fuel supplied that the observed variations of the solar heat may arise?—and may it not be in consequence of such changes in the thermal condition of the photosphere that the extraordinary convulsions revealed to us as sun-spots occur?

The views here advocated could not be thought acceptable unless they furnished at any rate a consistent explanation of the still somewhat mysterious phenomena of the zodiacal light and of comets. Regarding the former, we should be able to revert to Mairan's views, the objection by Laplace being met by a continuous outward flow from the solar equator. Luminosity would be attributable to particles of dust emitting light reflected from the sun, or to phosphorescence. But there is another cause for luminosity of these particles, which may deserve serious consideration. Each particle would be electrified by gaseous friction in its acceleration, and its electric tension would be vastly increased in its forcible removal, in the same way as the fine dust of the desert has been observed by Dr. Werner Siemens to be in a state of high electrification on the apex of the Cheops Pyramid. Could not the zodiacal light also be attributed to slow electric discharge backward from the dust toward the sun?—and would not the same cause account for a great difference of potential between the sun and earth, which latter may be supposed to be washed by the solar radial current? May not the presence of the radial solar current also furnish us with an explanation of the fact that hydrogen, while abounding apparently in space, is practically absent in our atmosphere, where aqueous vapor and carbonic acid, which would come to us directly from the sun, take its place? An action analogous to this, though on a much smaller scale, may be set up also by terrestrial rotation, giving rise to an electrical discharge from the outgoing equatorial stream to the polar regions, where the atmosphere to be pierced by the return flood is of least resistance. Thus the phenomenon of the aurora borealis or northern lights would find an easy explanation.

The effect of this continuous outpour of solar materials could not be without very important influences as regards the geological conditions of our earth. Geologists have long acknowledged the difficulty of accounting for the amount of carbonic acid that must have been in our atmosphere, at one time or another, in order to form with lime those enormous beds of dolomite and limestone, of which the crust of our earth is in great measure composed. It has been calculated that, if this carbonic acid had been at one and the same time in our atmosphere, it would have caused an elastic pressure fifty times that of our present atmosphere; and, if we add the carbonic acid that must have been absorbed in vegetation in order to form our coal-beds, we should probably have to double that pressure. Animal life, of which we find abundant traces in these "measures," could not have existed under such conditions, and we are almost forced to the conclu-

sion that the carbonic acid must have been derived from an external source.

It appears to me that the theory here advocated furnishes a feasible solution of this geological difficulty. Our earth being situated in the outflowing current of the solar products of combustion, or, as it were, in the solar chimney, would be fed from day to day with its quota of carbonic acid, of which our local atmosphere would assimilate as much as would be necessary to maintain it in a carbonic-acid vapor density balancing that of the solar current; we should thus receive our daily supply of this important constituent (with the regularity of fresh rolls for breakfast), which, according to an investigation by M. Reiset, communicated to the French Academy of Sciences by M. Dumas on the 6th of March last, amounts to the constant factor of one ten-thousandth part of our atmosphere. The aqueous vapor in the air would be similarly maintained as to its density, and its influx to, or reflux from, our atmosphere would be determined by the surface temperature of our earth.

It is also important to show how the phenomena of comets could be harmonized with the views here advocated, and I venture to hope that these occasional visitors will serve to furnish us with positive evidence in my favor. Astronomical physicists tell us that the nucleus of a comet consists of an aggregation of stones similar to meteorites. Adopting this view, and assuming that the stones have absorbed in stellar space gases to the amount of six times their volume, taken at atmospheric pressure, what, it may be asked, will be the effect of such a divided mass advancing toward the sun at a velocity reaching in perihelion the prodigious rate of 366 miles per second (as observed in the comet of 1845), being twenty-three times our orbital rate of motion? It appears evident that the entry of such a mass into a comparatively dense atmosphere must be accompanied by a rise of temperature by frictional resistance, aided by attractive condensation. At a certain point the increase of temperature must cause ignition, and the heat thus produced must drive out the occluded gases, which in an atmosphere 3,000 times less dense than that of our earth would produce $6 \times 3,000 = 18,000$ times the volume of the stones themselves. These gases would issue forth in all directions, but would remain unobserved except in that of motion, in which they would meet the interplanetary atmosphere with the compound velocity, and form a zone of intense combustion, such as Dr. Huggins has lately observed to surround the one side of the nucleus, evidently the side of forward motion. The nucleus would thus emit original light, whereas the tail may be supposed to consist of stellar dust rendered luminous by reflex action produced by the light of the sun and comet combined, as foreshadowed already by Tyndall, Tait, and others, starting each from different assumptions.

Although I can not pretend to an intimate acquaintance with the

more intricate phenomena of solar physics, I have long had a conviction, derived principally from familiarity with some of the terrestrial effects of heat, that the prodigious dissipation of solar heat is unnecessary to satisfy accepted principles regarding the conservation of energy, but that solar heat may be arrested and returned over and over again to the sun, in a manner somewhat analogous to the action of the heat recuperator in the regenerative engine and gas-furnace. The fundamental conditions are:

1. That aqueous vapor and carbon compounds are present in stellar or interplanetary space.

2. That these gaseous compounds are capable of being dissociated by radiant solar energy while in a state of extreme attenuation.

3. That the vapors so dissociated are drawn toward the sun in consequence of solar rotation, are flashed into flame in the photosphere, and rendered back into space in the condition of products of combustion.

Three weeks have now elapsed since I ventured to submit these propositions to the Royal Society for scientific criticism, and it will probably interest my readers to know what has been the nature of that criticism and the weight of additional evidence for or against my theory.

Criticism has been pronounced by mathematicians and physicists, but affecting singularly enough the chemical and not the mathematical portion of my argument; whereas chemists have expressed doubts regarding my mathematics while accepting the chemistry involved in my reasoning.

Doubts have been expressed as to the sufficiency of the proof that dissociation of attenuated aqueous vapor and carbonic acid is really effected by radiant solar energy, and, if so effected, whether the amount of heat so supplied to the sun could be at all adequate in amount to keep up the known rate of radiation. It was admitted in my paper that my own experiments on the dissociation of vapors within vacuous tubes amounted to inferential rather than absolute proof; but the amount of inferential evidence in favor of my views has been very much strengthened since by chemical evidence received from various sources; and I will here only refer to one of these.

Professor Piazzi Smyth, the Astronomer Royal for Scotland, has, in connection with Professor Herschel, of Newcastle, recently presented an elaborate paper or series of papers to the Royal Society of Edinburgh "On the Gaseous Spectra in Vacuum-Tubes," of which he has kindly forwarded me a copy. It appears from these memoirs that when vacuum-tubes, which contain attenuated vapors, have been laid aside for a length of time, they turn practically into hydrogen-tubes. In another very recent paper presented to the Royal Society of Edinburgh, Professor Piazzi Smyth furnishes important additional proof of the presence of oxygen in the outer solar atmosphere, and gives an ex-

planation why this important element has escaped observation by the spectroscope. Additional proof of the existence of oxygen in the outer solar atmosphere has been given by Professor Stoney, the Astronomer Royal for Ireland, and by Mr. R. Meldola in an interesting paper communicated by him to the "Philosophical Magazine," in June, 1878.

As regards the sufficiency of an inflowing stream of dissociated vapors to maintain solar energy, the following simple calculation may be of service: Let it be assumed that the stream flowing in upon the polar surfaces of the sun flashes into flame when it has attained the density of our atmosphere, that its velocity at that time is 100 feet per second (the velocity of a strong terrestrial wind), and that in its composition only one twentieth part is hydrogen and marsh-gas in equal proportions, the other nineteen twentieths being made up of oxygen, nitrogen, and neutral compounds. It is well known that each pound of hydrogen develops in burning about 60,000 heat-units, and each pound of marsh-gas about 24,000; the average of the two gases mixed in equal proportion would yield, roughly speaking, 42,000 units; but, considering that only one twentieth part of the inflowing current is assumed to consist of such combustible matter, the amount of heat developed per pound of inflowing current would be only 2,100 heat-units. One hundred cubic feet, weighing eight pounds, would enter into combustion every second upon each square foot of the polar surface, and would yield $8 \times 60 \times 60 \times 2{,}100 = 60{,}480{,}000$ heat-units per hour. Assuming that one third of the entire solar surface may be regarded as polar heat-receiving surface, this would give 20,000,000 heat-units per square foot of solar surface; whereas, according to Herschel's and Pouillet's measurements, only 18,000,000 heat-units per square foot of solar surface are radiated away. There would thus be no difficulty in accounting for the maintenance of solar energy from the supposed source of supply. On the other hand, I wish to guard myself against the assumption that appears to have been made by some critics, that what I have advocated would amount to the counterpart of "perpetual motion," and therefore to an absurdity. The sun can not of course get back any heat radiated by himself which has been turned to a purpose; thus the solar heat spent upon our earth in effecting vegetation must be absolutely lost to him.

My paper presented to the Royal Society was accompanied by a diagram of an ideal corona, representing an accumulation of igneous matter upon the solar surfaces, surrounded by disturbed regions pierced by occasional vortices and outbursts of metallic vapors, and culminating in two outward streams projecting from the equatorial surfaces into space through many thousands of miles. The only supporting evidence in favor of this diagram were certain indications that may be found in the instructive volume on the sun by Mr. R. A. Proctor. It was therefore a matter of great satisfaction to me to be informed, as I have been by an excellent authority and eye-witness,

that my imaginary diagram bore a very close resemblance to the corona observed in America on the occasion of the total eclipse of the sun on the 11th of January, 1880.

Enough has been said, I think, to prove that the theory I have ventured to put forward is the result, at any rate, of considerable reflection; and I may add that, since its first announcement, I have not seen reason to reject any of the links of my chain of argument: these I have here endeavored to strengthen only by additional facts and explanations.

If these arguments can be proved to the entire satisfaction of those best able to form a judgment, they would serve to justify the poet Addison when he says:

"The unwearied sun from day to day
Does the Creator's power display,
And publishes to every land
The work of an Almighty Hand."

—*Nineteenth Century.*

THE FUTURE OF MIND.*

By PETER BRYCE, M. D.

BUT what does science testify as to the probable future of mind in earthly life? Have mind and body attained their supreme development? Is humanity a fixed entity, incapable of essential modifications or improvement? All the evidence goes to show that the improvement of the human race is practically illimitable. This is true both of mind and body, which, as has been shown, advance *pari passu*, and is made very evident by the fact that the pre-eminence of Europeans over barbarous races, which is so manifest in their intellect, is just as manifest in their anatomy and physiology. There is a diversity of proofs of the advance of the physical man in modern times. No one questions that the average duration of life is being steadily prolonged. Besides a multitude of new arts and new sciences, all the arts and sciences known to the ancients have been so wondrously developed as to seem like new creations of the modern man. Geology, zoölogy, botany, chemistry, geography—physical and political—medicine, painting, politics, theology, etc.—every department, in fact, of human interest—have grown, as it were, into new and marvelous revelations. But to suppose that these immense developments of art and science can have resulted without corresponding improvements in the human intellect, is to ignore very important biological principles.

* From a discourse on "Some of the Phenomena of Mind," delivered before the Medical Association of the State of Alabama, April 11, 1882, by Dr. Peter Bryce, Superintendent of the Alabama Insane Hospital, etc.

As an advanced science implies an advanced art—the progress of the two being ever conditioned upon each other—so the great advances of the sciences and arts imply a corresponding development of human intelligence. The principle of action and reaction prevails in the world of mind as in the world of matter, and while the human intellect, by cogent applications of its powers, has established multitudinous differentiations in things once inextricably intermingled, a corresponding differentiation and specialization of its own powers has inevitably resulted. But specialization of functions being the direct evidence of its greater perfection, it is incontrovertible that the multiplication of specializations of knowledge by human inquiry has resulted in improvements of the powers of the human mind. The strain now put on human power to keep pace with the advances already made is an assurance that there will be in the future no lack of occasion for continued mental development. All departments of human enterprise have in truth been already so marvelously developed as to defy the complete grasp of any but specialists of more than ordinary capacity. Croakers may find fault and stigmatize the advance of the age as mainly material. Never did carping criticism have poorer ground for its averments. The material advance is fully matched by the moral advance. Proofs of it are so multiplied as scarcely to deserve enumeration. Liberty to think boldly and to give free utterance to honest convictions is fast becoming a sacred principle of society. Liberty of person, and equal justice—irrespective of rank and wealth—are now almost everywhere recognized as divinest principles of government. The sick and the unfortunate, instead of being left to die without aid or to pine through a miserable existence, are now everywhere provided for at the expense of those whom fortune has subjected to less severe trials. Sumptuary laws are now not only known to be useless but their principle is condemned. Private war has almost ceased to be waged; and the duty of revenge, once sanctioned by religion, has given place to the duty of forbearance and forgiveness. The well-being of one's neighbor is now universally felt to be the good fortune of one's self. Vast accumulations of wealth, instead of being squandered in the purchase of places and useless decorations for elevating one's self above his fellows, are now employed in educational, industrial, and eleemosynary foundations.

Nor is this true of individuals only. Governments, both monarchical and republican, instead of employing their resources in war and destruction, are now rivals in the most beneficent achievements for prolonging and ennobling human life. Slavery has been abolished in nearly every civilized country, and all forms of privileged oppression are rapidly meeting with the same condemnation. In truth, such has been the progress of morals and the general assimilation of the principles of equity, that the most important functions of life and society are now accomplished without the intervention of government,

giving promise of a gradual declension of the functions of the central power before the more precise and equitable supervision of society constituted of individuals imbued with ever-present aspirations for justice and advancement. Already this day of a new excellence has dawned, and there are not a few indications that new crystallizations of social forces are destined to supervene. The liberation of woman from her ancient servitude and her rapid advance to every privilege for which her powers adapt her, the emancipation of children from the severe domestic tyrannies and cruelties to which they were time out of mind subjected, are striking evidences of the ameliorations due to general moral advance. Like the animal organism the social organism responds throughout its whole substance to any force brought to bear upon it, and the influence of scientific methods of thought is destined to exert upon society augmenting influences of the most pervading and salutary kinds. Truth and morality are inextricably intermingled, and whatever aids in the discovery of truth is a potential moral adjuvant. As, in Scripture, condemnation and the belief in lies are everywhere conjoined, so moral advance is ever assured by devices that accomplish the enlargement of the realm of truth. To carp at scientific methods is to carp at truth, for scientific methods are only severe procedures for the discovery of truth; and there is, to my mind, little doubt that in no great while the much-desired reconciliation of natural with revealed truth will be successfully achieved. I find in late utterances of scientific men of the highest stamp much that is in conformity with some of the prevalent teachings of religion. Herbert Spencer is unquestionably the most perfect embodiment of advanced scientific thought. While in special departments there are many that go before him, in the power of co-ordinating the various sciences and embodying their myriad diverse facts into a consistent body of philosophy he goes far before all his contemporaries. His writings, indeed, stand apart as a great mountain-range looming far above the lesser heights. It would be easy, from Mr. Spencer's writings, to accumulate declarations that have wondrous congruity with orthodox doctrine. The worship of humanity, Mr. Spencer declares, can never take the place of the worship of God. He also affirms, with all our orthodox creeds, that precepts of right living do little or no good unless the corresponding emotion can in some way be roused. His standard of right conduct, scientifically deduced, is a perfect law of righteousness which may not be debased below the mark of perfection, however unable men and women may be to fulfill its requirements.

In every aspect, therefore, the prospect of human advancement is very cheering. Individually and collectively man is so steadily progressing to the achievement of the great problem of his life—perfect conformity to the conditions of his being—that no mad enthusiasm is needful to prompt the anticipation of a rapid advance to that condition

of things which the ancient seers foresaw and aspired toward, when "they shall beat their swords into plowshares, and their spears into pruning-hooks: nation shall not lift up the sword against nation, neither shall they learn war any more."

But, while science is disclosing the methods of mind, and preparing for it on earth a nobler and still more noble *rôle*, what are its testimonies as to the duration of mind—its immortality? Some of the most devoted adherents of scientific methods have reached conclusions which are unfavorable to mind's immortality. But it is not surprising, in view of the novelty and marvelousness of many lately demonstrated scientific truths, that even men of calm temper should be led to attach undue importance to them—to claim for them reaches and meanings which do not of right belong to them. Close as may be the demonstrated union between mind and body, no philosophy of organization and life satisfactorily accounts for the presence of mind. Mind is indeed unique, peculiar; has its own laws, and overleaps and undermines all mere material phenomena. The study of mind is, therefore, incomplete unless subjectively pursued. The mind must be questioned, must testify of itself, if we would arrive at anything approaching just conclusions with reference to it. This is indisputable from the fact that mind is that mysterious quality in us by which we explore all material phenomena. It is only, therefore, by due attention to mind's subjective contemplation that we gain the right to reason upon the phenomena of material things. A surveyor who should go around determining boundaries, directions, and areas, without having first put to severe tests his compass and chains, would be acting not a whit more absurdly than they who leave out of the study of material and mental phenomena a subjective study of mind. But, if only by questioning mind about itself we can rightly understand its nature, dare we, in conducting the inquiry, ignore a whole host of its most prominent intuitions? Surely not. But mind's testimony of itself is, that there are in it indefeasible principles of individuality, responsibility, and immortality. It would be strange, indeed, if this noble, this intensely royal, thing, which disdains to be classed with any material forces, however sublimated they may be, should be remanded to the companionship and fate of the phenomenal, the sensual, the perishing!

Happily for the theory of evolution, not all nor even the majority of its advocates have given assent to such conclusions. Mr. Darwin has ever conjoined with his marvelous disclosures of the relations of organic facts a spirit of religious reverence. Mr. Herbert Spencer avows that there are unseen, eternal verities which justify religion. Lessing, David Strauss, and Professor Helmholtz, could not reconcile themselves to the thought of a final destruction of the living race, and, with it, all the fruits of all past generations. Others among them, however, assume that, since mind is only known to us as a phenomenon

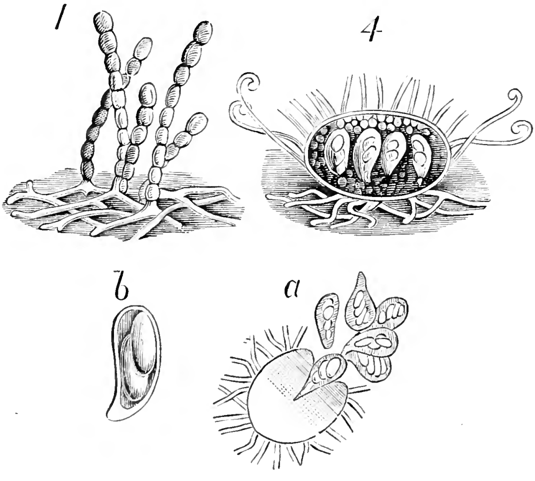
of organism, the death of the organism involves a discontinuance of all its functions—thought, affection, and will, not excepted—and their resolution into the more primitive forces from which they originally sprang. But it is clearly a most unwarranted assumption that spiritual individuality—the fundamental principle of which no one pretends to apprehend—can not be prolonged or perpetuated, except under such material circumstances as earth supplies. If it be recollected how ignorant man is of the essences of matter and motion, and that there are in mind or spirit qualities which can not be ranged with material things, or with their almost infinitely subtile forces, we will readily see that the assumption of no conscious life except under such circumstances as material things supply is most unwarrantable.

Even the argument against immortality, based upon the relations of mind to organism, when closely examined, loses much of its seeming fitness. The persistence of force is, indeed, as much an axiom of science as the indestructibility of matter. What appears to be cessation of force is simply its transformation into other forces. But muscular movements provoked by volition are not actuated by mental force. The mind, in voluntary motions, does not supply the force. It only signals the nerve-centers that furnish the force. The centers of motion, which have of late been demonstrated in the brain, do not supply the force for the operation of the muscles, whose contractions they specially control. The brain-centers are properly only intellectual signal-centers—centers whence issue the volitions that liberate the forces of the lower nerve-centers for contracting special muscles. Fatal errors in reference to mind may easily grow from confounding nervous force with mental force. It is impossible to form right conceptions of mind so long as it is regarded as a merely resultant force made up of the organic forces which lead up to it. In any such conception there is left out an important element which it is difficult explicitly to define, but which may be forcibly suggested by a comparison. The beautiful form—symmetry and proportions—of a noble tree may be regarded apart from the organic materials and forces which underlie it. Thus regarded it is, as it were, spiritual, and is capable of arousing conceptions of beauty and grandeur in the soul of the beholder. Mind, in this view, instead of a mere force, becomes a symmetrical and living expression of the relations of the myriad forces which have from the very beginning entered into the life. It is, therefore, in one view, as absolutely immaterial as the form and beauty of a tree. But in still another aspect mind must be considered a higher and vastly more subtile force than any physical forces with which we are acquainted, and in its actions and methods of development is governed by laws peculiarly its own. Mind or mental force is, therefore, unique, and stands apart as a grand exception to the general law of the correlation of forces. But, as all the physical forces are persistent in some form or other, it is eminently unreasonable to suppose that this peculiar force,

that immeasurably transcends all others, should alone undergo absolute extinction. It needs must be, therefore, that mind or mental force shall continue to exist after dissolution of the organism with which its manifestations are associated, by passing into a new state, or new conditions of activity, of which science takes no cognizance. Thus considered, mind, in its ultimate analysis, becomes a purely spiritual entity which can never be dissolved and commingled with the heterogeneous forces of the material world.

ABOUT THE MOLDS.

THE molds represent an immense variety of minute plants that grow upon a great number of objects, and under different circumstances. The spores from which they are developed are borne in the air, imperceptibly to us because of their extreme littleness. The microscopic examination of them reveals some very curious dispositions and forms, always worthy of admiration. We often, in the spring, perceive blades of grass covered with a chalk-like dust, so white that one is at first sight inclined to take it to be hoar-frost. On examining it with a microscope of small power, we shall perceive a real forest of



minute plants. Little bundles of very delicate filaments, clear and crystalline, composed of roundish cells connected together, rise from a net-work of other branching filaments, which are collectively called the *mycelium* (Fig. 1). These curious organisms are the first phases of a parasitic plant belonging to the great order of the cryptogams, or a

fungus. A mold that has caused great damage to grape-vines—the *Oidium Tuckeri*—is an incompletely developed fungus.

A whitish substance may be remarked on the leaves of lilacs near the middle of the summer, which might be regarded on superficial observation as dust from the road. It is also a mold. The microscope shows it to be made up of very delicate threads, similar to those of spiders' webs. As these threads become older, we may observe joined to them a number of little spheroidal bodies, some very small and white, others larger and yellow, and others brown. The white and yellow corpuscles are young fruits of the fungus, and the brown ones are ripened fruits. If one of the last is put into a drop of water and pressed between two glasses for mounting microscopic preparations, it will let escape some small pyriform, transparent sacs, each inclosing spores, the number of which varies according to the species, but is definite for each species. The arrangement of these spore-containing sacs (*sporangiæ*) is shown by the vertical section (Fig. 4). The number of *sporangiæ* (*b*) contained in each of the fruits varies in different species from one to twenty and more.

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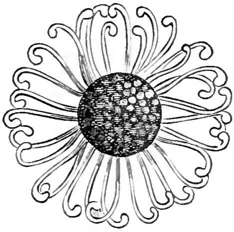

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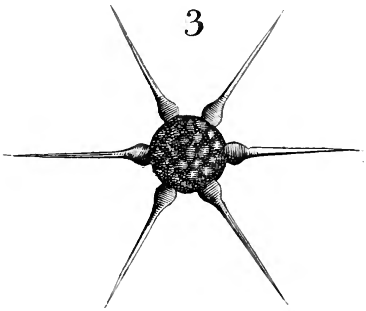

Aside from every scientific consideration, a great interest is given to these plants by the beauty of their ornamentation; and they form

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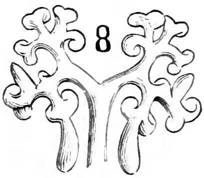

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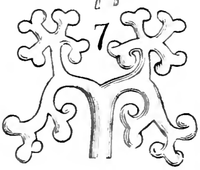


choice objects for preparations. Around each receptacle may be seen numerous appendages radiating in every direction, and generally uncolored. In some genera these appendages are long and flaky, while other genera have only six or eight of them in the form of short needles

projecting from a bulbous base (Fig. 3). The extremities of the needles in other species are curved and turned over, as in Figs. 2 and 5, and in others they are one or two times branched; while in the genus *Microsphæria* the extremities of the appendages take the most varied and most exquisite forms (Figs. 6, 7, 8, and 9).

The life and history of these little plants afford a large field for studies and investigations, which are within the reach of every one who has a good microscope, and is not engaged on any other special study. Such researches are, moreover, of great practical value. The parasitic fungi are one of the great plagues of agriculture. They fix themselves in hosts upon leaves and fruits, where they shut up the stomata and prevent the action of air and light. The hope of discovering a remedy for such evils is dependent on the study of their causes.

THE INTRODUCTION OF DOMESTIC ANIMALS.*

THE roving shepherd sows hastily a piece of land, which he leaves after harvesting his crop, to do the same the next year with another piece of land. But, when fruit-growing is combined with agriculture, this unsettled shepherd-life becomes entirely changed. The plantation of trees and vines must be inclosed, and taken care of a long time before it will bring fruit. Hence arises the sense of a settled home and of individual possession. Even the house of the planter becomes a firmer structure; the ground is more thoroughly cultivated, so that a smaller territory suffices to support the family, and individuals combine more and more into social communities. Man thus becomes accustomed to a settled order of life, and to the relations which form the foundation of lawful constitutions. Closely associated with these changes in the mode of living is the introduction of domestic animals.

In the early time, when the tribes of the Indo-European people still formed one undivided folk in its Asiatic home, the sheep and the cow had already been tamed. This is proved in the case of the sheep by the numerous varieties existing among them. The word *daughter*, which means "the milker," and which is common to all the Indo-European languages, bears witness to the early taming of the cow. Of both these animals, man at first used only the milk, the flesh, and the skin. Afterward the cow became man's assistant in agriculture. It was not until a much later time that the horse took the place of the cow, at first chiefly in traveling and in riding, afterward more and more in agricultural operations. Here, however, arises the important question, whether the people already possessed these tamed animals

* Translated from the German.

when they moved into the several parts of Europe, or were they first received by them at a later time.

There is no doubt that the original home of the horse is not Europe, but Central Asia; for since the horse in its natural state depends upon grass for its nourishment and fleetness for its weapon, it could not in the beginning have thriven and multiplied in the thick forest-grown territory of Europe. Much rather should its place of propagation be sought in those steppes where it still roams about in a wild state. Here, too, arose the first nations of riders of which we have historic knowledge, the Mongolians and the Turks, whose existence even at this day is as it were combined with that of the horse. From these regions the horse spread in all directions, especially into the steppes of Southern and Southeastern Russia and into Thrace, until it finally found entrance into the other parts of Europe, but not until *after the immigration of the people.* This assumption is, at least, strongly favored by the fact that the farther a district of Europe is from those Asiatic steppes, i. e., from the original home of the horse, the later does the tamed horse seem to have made its historic appearance in it. The supposition is further confirmed by the fact that horse-raising among almost every tribe appears as an art derived from neighboring tribes in the East or Northeast. Even in Homer the ox appears exclusively as the draught-animal in land operations at home and in the field, while the horse was used for purposes of war only. Its employment in military operations was determined by swiftness alone. That the value of the horse must originally have depended on its fleetness, can easily be inferred from the name which is repeated in all the branches of the Indo-European language, and signifies nearly "hastening," "quick." The same fact is exemplified by the descriptions of the oldest poets, who, next to its courage, speak most of its swiftness. How beautiful, for example, is the description in Homer!—

> ". . . As when some courser, fed
> With barley in the stall, and wont to bathe
> In some smooth-flowing river, having snapped
> His halter, gayly scampers o'er the plain,
> And in the pride of beauty bears aloft
> His head and gives his tossing mane to stream
> Upon his shoulders, while his flying feet
> Bear him to where the mares are wont to graze."
> *Iliad* (Bryant's translation, vi, 644–651).

And what lofty words does the author of the book of Job use in speaking of this animal!—

> "He mocketh at fear, and is not affrighted;
> Neither turneth he back from the sword.
> The quiver rattleth against him,
> The glittering spear and the shield.

He swalloweth the ground with fierceness and rage:
Neither believeth he that it is the sound of the trumpet.
He saith among the trumpets, Ha, ha;
And he smelleth the battle afar off, the thunder of the
captains, and the shouting."
(Chapter xxxix, verses 22–25.)

It was chiefly by reason of these two properties—fleetness and courage—that the horse quickly became an animal without which history would seem barren enough. Without the horse neither the expeditions of an Alexander, nor a migration of tribes, nor a Christian knighthood, would have been possible; in a word, without the horse, all those mighty movements which have shaken the world and have stirred the very foundations thereof, could never have been thought of; and the people, sitting still and silent upon the ground, would never have left their accustomed boundaries to go forth fighting and colonizing from land to land.

Happily the horse possessed still other important properties which rendered possible its employment in other than warlike uses. Chief among these properties are its sagacity, endurance, and fidelity. When, therefore, war was no longer the chief employment of Europeans, and agriculture had taken its place, man soon thought of employing the horse as a draught-animal as he in like manner had hitherto used the cow. Then did the horse become, for the first time, of real use to culture, and a leading actor in it. Such had not been the case in Asia up to this time. The ox had drawn the plow and wagon but lazily and slowly, and agriculture had made slow progress; but with the horse came a new impulse, a higher purpose in this occupation, which made it an important and valuable one. Even to this time the horse, by reason of his excellent properties, is regarded as the truest companion and aid of man in all the operations as well of war as of agriculture. Neither is this noble animal to be forgotten in commerce and trade, nor in art; in a word, it is the most valuable and therefore the best treated domestic animal which Europe has to exhibit.

Besides the horse, some other animals, which in the pastoral time had not yet entered Europe, soon made their appearance. They were the ass, with its near relative the mule, and the goat. All these wandered, as did the vine, fig, and olive, from Asia Minor and Syria to Greece; and, strange as it may seem, the mule preceded the ass, whose original home may after all have to be sought for in Africa. Both spread at a later date from Greece into the same regions in which the vine and the olive found their way, and for a time did not pass beyond these regions. For, notwithstanding their patience and contentment, by virtue of which they are satisfied with the most wretched food, they did not find the climate in Northern Europe a hospitable one for them, and are both still really strangers there.

The goat, too, on account of its predilection for young trees, buds, and sharp, aromatic herbs, can be kept in great numbers only in those regions in which the injuries inflicted by them are of relatively little importance. It therefore feels more at home in the rocky labyrinths of the Grecian islands, Sicily, Sardinia, and Italy, than in the northern regions. According to the census, Italy in 1863 possessed forty-one million goats.

Of four-footed animals, Europe has received only one further addition—the cat. Unlike the dog, it was most probably not a primitive companion of man, but is relatively a late gain. The taming of the animal is a fruit of the religious customs of the Egyptians, who recognized the worth of this mouse-destroyer, and permitted divine honors to be paid to it. Its picture, therefore, meets us beside other wonderful figures upon numerous Egyptian monuments, and in the tombs whole layers of cat-mummies are sometimes to be found.

The ancient Greeks were not acquainted with the cat, but the mouse was certainly known to them from the earliest period—a fact shown by the name which is common to all the Indo-European languages, and which signifies apparently "thief"—and they not seldom suffered so severely under the plague of these pests that whole regions were devastated and in consequence had to be abandoned. For the destruction of the mice they used either the weasel or the marten, which were tamed for this purpose. The weasel, especially, held just the same place among them that the cat now holds among us, and it passed in like manner into proverbs and fables. In Aristophanes, a certain person is summoned to tell a story, and he begins his fable with the words—

"There was once a mouse and a weasel."

That the cat was as little known as a domestic animal to the Romans as it was to the Greeks, is plainly shown by the story of the country and the city mouse, as narrated by Horace, who lived in the time of Augustus. There is certainly no question that if Horace had known the cat he would have mentioned it in this passage, but no mention of it is made. In the fourth century A. D., we find the cat mentioned for the first time among the domestic animals, and it not only spread abroad among all the European peoples, but was also transplanted to Asia. If Hehn's conjecture be correct, its general introduction was occasioned by the irruption of the rat, which seems to have entered Europe in company with the immigrants from Asia.

Among the Germans this animal was allotted to Freya, whose carriage was drawn by two cats. At the same time it was regarded as a shrewd, magic-working animal, and it therefore played a leading part in matters of witchcraft, during the middle ages, beside the owl and the bat, in myths that grew plainly enough out of its sneaking movement, its preference for the night, its dark fur, and its eyes, which glow in the dark. Cats guarded secret treasures in mountains and

caves, they lay at cross-roads, at night they carried on their operations in ruined mills in the forest; even witches and magicians assumed their forms in order either to inflict injury upon others or to visit the Blocksberg. The German fables of animals allot to the cat the prize for wisdom and deception. When it becomes necessary to bring the robber Reynard to court to make an end to all his evil deeds and the complaints arising therefrom, and Brown, i. e. Bruin, the bear has failed in the attempt, then it appears that only Harry, the cat, is able to accomplish the task of delivering the artful message to the evil-doer. Again, the cat does not lack certain desirable qualities. How burdensome does the dog with its caresses often become, how unskillfully does he exert himself to please; how gentle and amiable, on the contrary, can the cat be, how pleasant its manner and motion! During the middle ages, therefore, the cat served as a plaything for distinguished ladies, who nursed it on their laps and fed it with dainty bits; and at the present time, among many persons, the cat finds recognition and love: in Gottfried Mind it has found its Raphael, and poets, like Tieck, Amadeus Hoffman, Lichtwer, and in recent times Scheffel, have ennobled their thinking and striving; who, for example, does not hold in grateful remembrance the deep philosophizing of the cat Hidigeigei (in Scheffel's "Trompeter von Säkkingen") on the theme "Why do men kiss?" Even Lessing's quaint nature could find a source of enjoyment in this animal; on his writing-table lay his cat, and no one can read without emotion how Lessing, when his favorite had destroyed the manuscript of "Nathan," patiently and quietly wrote the poem anew without depriving the author of the mischief of its usual place. Notwithstanding this, for most men there is something demoniacal and weird about the animal, which withdraws it from their sympathy; hence Massius rightly says of it, "Complicated by the favor of parties and by their hate, its character in history wavers."

Among manifold other varieties of animals, birds have always excited in a marked degree the attention and the favor of man. Since the primeval time hosts of songs have been sung to the lark, the stork, the nightingale, and the swallow, and the speech of people greets them in their flight with a thousand fond, familiar words. Nay, it is not too much to assert that, without the birds, even the spring-time would be sad, just as by their flight the winter becomes so much the more gloomy and desolate. But that which most attracts us to birds is their power of song and of flight. In ancient times favored men pretended to understand their mysterious sounds, which were to them the voice of Fate, since they seemed either to encourage by a cheerful address or to warn by threatening tones. The flight especially seemed to be supernatural and worthy of admiration, and there has certainly been no lack of attempts to imitate it, as the myth of the Greeks regarding Dædalus and Icarus shows. But it was precisely

this power of flight, and the impulse to wander connected therewith, which made it impossible for man to draw the majority of fowls into closer relations with himself, and to make them useful to him. He was in reality able to domesticate only those which had lost more or less the power to fly, or those which had in only a slight degree the character of flying animals, and were not compelled to change their dwelling-place in winter. Thus our presentation is limited to the few which are now regarded as really domestic animals—viz., to the goose, duck, turkey, and peacock.

Although the taming of the goose and the duck reaches back to a very early period—since neither of them was brought hither from Asia, but both are descended from our native wild varieties—the fowl, or chicken, is of comparatively recent date in Europe. In the Old Testament, and upon the Egyptian monuments, it is not to be found. It appeared first in India, and gradually spread farther westward, where it gained much respect, especially among the Persians. In the religion of Zoroaster the cock was sacred, being regarded as the herald of the morning and a symbol of light, because he drove away the evil spirits of darkness.

In Homer and Hesiod, and in general in the oldest Greek poets, we find no trace of the fowl. It seems to have been first mentioned by Theognis (about 600 B. C.), and was universally known to the contemporaries of the Persian War. The comparison between the fights of cocks and of men is a favorite one with the poets of that period.

Themistocles is said to have once stirred the courage of his army by pointing to two fighting cocks which staked their lives for the glory of victory, and not for their hearths and gods. It agrees well with its late introduction that the cock has attained to but little importance in cultivated circles: he was sacred to Ares (Mars), and people were accustomed, after recovery from sickness, to bring to Æsculapius, the god of medicine, a cock as a sacrifice.

From Greece the fowl quickly found its way into Sicily and Lower Italy; only the Sybarites, who were notorious gluttons, are said to have admitted no fowl within their walls, so that they might not be disturbed in their sleep.

Among the Romans the fowl played a very important part: sacred cocks accompanied the departing commanders to the scene of war, and were used for taking the auspices. It was considered a favorable sign if the fowls ate greedily; but, on the other hand, it denoted a misfortune if they refused food. It will thus be readily seen that the attendant of these birds (*pullarius*) exercised much influence in this matter, according as he did, or did not, give the fowls food before the taking of the augury.

How widely the breeding of fowls spread and developed in Italy may be learned from the writings of Varro and of Columella. Fowls, and especially fighting-cocks, were constantly imported from places

which had become noted for breeding them—e. g., Rhodes, Chalcis, Delos—or directly from Persia.

That the fowl did not come into Germany from Italy, but that a more direct transfer of it from Persia—perhaps by way of Thrace, Illyria, and Pannonia—must have taken place, is shown by the names (*hahn*, *huhn*, *henne*), which are independent of, and different from, the Greek and Latin names; and it is further shown by the ideas and representations which, in the North, are connected with the fowl. Thus we find in separate and distinct places the same belief as in Persia—that the cock, by his crowing, frightens away the evil spirits; he was the symbol of flame, the animal of Loki, the god of fire: when he unfolded his wings, conflagrations started up under him, whence comes the still current expression for an act of incendiarism, "To set the red cock upon any one's roof." Cæsar reports of the Britons that among them, just as among the Persians, no one was allowed to eat the flesh of fowls. At what time, however, the northern immigration took place can not be accurately stated; yet the supposition can not be wide of the truth that it was when the Persians, during their expeditions to Greece, came into contact with the above-named tribes—somewhere about the fifth century B. C. From that starting-point, then, this useful domestic animal soon spread abroad everywhere, and found always the most ready reception wherever man was about to change from a nomadic shepherd-life and have a settled, permanent home. At present the breeding of fowls receives most attention in France, which country is said to support, at the lowest calculation, 100,000,000 fowls—a striking example of what an important part in the economical life of a people this animal is capable of playing.

The peacock, too, is a native of Asia, having come to us from India. Phœnician ships, so early as the time of Solomon, brought it to the coast of the Mediterranean Sea. The first place in which peacocks were kept in Greece seems to have been the temple of Hera in Samos, for there, according to mythology, this bird had its origin. That the peacock was dedicated to Hera can not astonish us, for she is the goddess of the starry heaven. Another myth related that the thousand-eyed Argus, the watcher of the moon goddess Io, had been slain by Apollo and changed into a peacock, or that Hera had placed his thousand eyes upon the feathers of her bird. Moreover, the peacock was very profitable for that temple of Hera, inasmuch as its plumage enticed thither many inquisitive sight-seers, who willingly paid the temple tribute for a sight of the beautiful bird. As a reward for this, the Samians placed its image upon their coins.

In Athens we find the peacock first mentioned in the fifth century B. C., and the contemporary writers fail to find sufficient words to tell what a surprise its appearance had made among that inquisitive and novelty-loving people. It is, therefore, not remarkable that, already in the fourth century B. C., peacocks were more numerous in Athens than quail.

The question, "By what way and by whom was the peacock brought into Italy?" is shrouded in deep darkness; and the supposition of Hehn, that it was brought thither directly from Phœnicia or Carthage, stands upon doubtful testimony. It was, however, cordially received and prized in that country, especially in the later times of senseless luxury. The orator Hortensius, a contemporary of Cicero, was the first to bring the peacock roasted upon the table, and, despite the lack of palatableness in its flesh, his example seems to have been extensively imitated.

From Italy the peacock found its way into the rest of Europe, and became in Christian lands the subject of a double symbol. On one side it was regarded as an emblem of immortality, for the story gained credence that its flesh was incorruptible; on the other hand, it served as an exhortation to humility, according to the well-known proverb, "The peacock has a brilliant coat of feathers, but do not look down at its feet."

Reference was made, too, to its sneaking walk and its vicious character, especially in old age. But the knight gladly adorned his helmet with its feathers, and the custom at great banquets of bringing to the table, amid the flourish of trumpets, a roasted peacock adorned with its own feathers, and of taking a vow thereupon, lasted down to the end of the middle ages. In more recent times, however, the bird, together with its flesh and its feathers, has fallen into discredit; and it is left to the Chinese mandarin to carry the peacock's feathers as a sign of rank.

HYDRODYNAMICS AND ELECTRICITY.

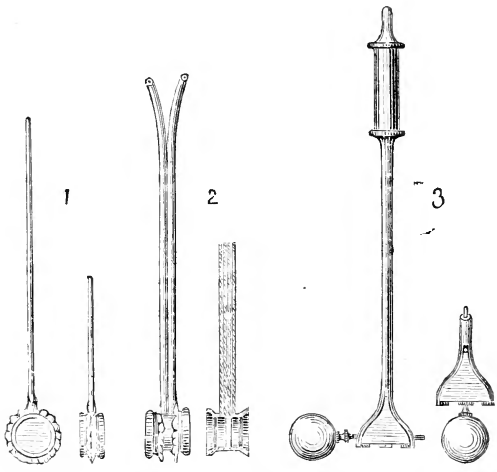
VISITORS at the recent Electrical Exposition in Paris were much interested in an apparatus exhibited by Dr. C. A. Bjerknes, of the University of Christiania, Norway, for the illustration of certain properties in hydrodynamics analogous to some of the manifestations of electricity and magnetism. Professor Bjerknes has been carrying on his investigations in this line for nearly twenty years, having published his first paper, "On the Internal Condition of an Incompressible Fluid in which a Sphere of Variable Volume is moving," in 1863, and having followed it up with numerous other papers relating to similar problems. The results of experiments in every case corresponded with those which had previously been indicated to him by mathematical calculations. The experiments had in view the study of molecular movements by reproducing mechanically, but in the inverse sense, as the results proved, the simple and fundamental electrical and magnetic phenomena.

Pulsating and oscillating bodies are applied so as to produce vibra-

tions in a trough of water about six inches deep. By pulsating bodies are meant those which undergo alternate changes of volume, marked by two distinct phases, one of swelling and one of contraction. The pulsations of the two bodies are spoken of as synchronous when the similar phases occur simultaneously in them. The oscillating bodies are constant in volume, but undergo alternate changes of place, from right to left and from left to right, or in a vertical direction.

Pulsations are communicated by means of little tambours or drums made of hollow cylinders of metal, over the ends of which are stretched flexible plates or membranes. These drums are made to swell and contract by means of pumps, with which they are connected by India-rubber tubing, that compress the air within them. Two drums are usually employed in the experiments, each connected with a separate pump, so that the rhythm of the pulsations may be regulated at will. Thus both drums may be caused to pulsate synchronously, or with an opposite rhythm. In the simplest pulsator (Fig. 1, 1) the two drum-

Fig. 1.



heads beat synchronously, or suffer dilatation and collapse together, as the pump is worked. In another disposition the drum-heads are separated by a rigid partition dividing the instrument into two chambers, each having its separate connection by a distinct tube, with a different pump, making it practicable to produce either synchronous or unsynchronous pulsations. A more common disposition is to use two simple pulsators in connection with the two pumps, one of which is held in the hand, while the other is mounted in the water, so as to be left free to move.

The two phases of pulsation are regarded by Professor Bjerknes as analogous to the poles of the electrode or magnet. The phase of dilatation may thus be likened to the north pole, that of collapse to the south

pole. If, now, having one of the drums mounted in the water, and the other held in the hand, we bring them near each other while both are dilating or both are contracting—that is, while both are in the same phase of pulsation—attraction will take place between them. The mounted drum will assume the direction of approach toward the one held in the hand, and of following it when it is removed; but if they are in opposite phases—if one is swelling while the other is contracting—they will be repelled. Like poles attract, unlike ones repel. The phenomena are the inverse of what are observed in ordinary electricity and magnetism, where unlike poles attract and like ones repel. The pulsating drum in these experiments represents an isolated pole, a conception which physicists have not hitherto regarded as possible.

Spheres of invariable volume, but adjusted so as to oscillate in either an horizontal or vertical direction, may be used instead of the pulsating drums, when the phenomena assume a modified shape. The oscillators used by Professor Bjerknes are mounted as in the figure (Fig. 1, 3), where the sphere on the left is arranged so as to oscillate horizontally, and the one on the right to oscillate vertically, the alternate movements of oscillation being produced, like the pulsations of the drums, by alternately forcing in and withdrawing the air. The opposite sides of the sphere assume opposite phases, and the sphere acts like a magnet. If a sphere is brought near a pulsator, so that its oscillating movement shall be toward the drum while that is dilating, attraction takes place; but, if it be turned in the opposite direction, so as to be moving away from the drum while the same is swelling, repulsion will be manifested.

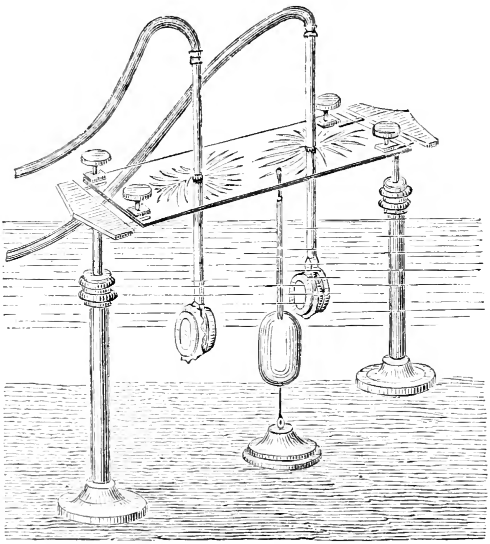
If two oscillating spheres be brought near each other, attraction takes place in case they are both moving to or from each other; repulsion, in case they are both moving in the same direction: and the change can be effected at once, as before, by turning one of the spheres around.

Professor Bjerknes has a considerable variety of apparatus for modifying the aspects of the phenomena by changing the relative situations of the bodies to each other, in all of which manifestations of an inverse character to those of ordinary magnetism are developed. If one of the spheres be mounted so as to be free to move about a vertical axis, it is found that, when a second oscillating sphere is brought near to it, the one that is free turns round its axis, and sets itself so that both spheres shall be simultaneously approaching or receding from each other. Two oscillating spheres mounted at the extremities of an arm, with freedom to move, behave with respect to another oscillating sphere exactly like a magnet in the neighborhood of another magnetic pole. These directive effects are believed by Professor George Forbes to be perfectly new, both theoretically and experimentally.

The phenomena of attraction and repulsion, described above, are

supposed by Professor Bjerknes and Professor Forbes to be due, not to the action of one body on the other, but to the mutual action of one body and the water in contact with it, the water being regarded as the analogue of Faraday's medium. "Viewed in this light," says Professor Forbes, "his first experiment is equivalent to saying that, if a vibrating or oscillating body have its motions in the same direction as the water, the body moves away from the center of disturbance; but, if in the opposite direction, toward it. This idea gives us the analogy of dia- and para-magnetism. If, in the neighborhood of the vibrating drum, we have a cork ball, retained under the water by a thread, the oscillations of the cork are greater than those of the water in contact with it, owing to its small mass, and are, consequently, relatively in the same direction. Accordingly, we have repulsion, corresponding to diamagnetism. If, on the other hand, we hang in the water a ball which is heavier than water, its oscillations are not so great as those of the water in its vicinity, owing to its mass, and consequently the oscillations of the ball relatively to the water are in the opposite direction to those of the water itself, and there is attraction corresponding to para-magnetism. A rod of cork and another of metal are suspended horizontally by threads in the trough, and a vibrating drum is brought near them: the cork rod sets itself equatorially, and the metal rod axially."

Fig. 2.



From these and other experiments Professor Bjerknes has concluded that the motion of a vibrating agent in the water produces a real magnetic field, with its lines of forces presenting, but always in an inverse sense, identical phenomena of diamagnetism and para-

magnetism, magnetic interference, etc. He has been able to trace out the direction of the lines of force produced in the liquid with the apparatus represented in Fig. 2. A light sphere or cylinder is mounted in the midst of the liquid upon an elastic rod, so that it shall partake of every movement of the surrounding water; a brush is attached to it, and arranged in such a manner as to paint, on the glass plate above, the line of every vibration of the fluid important enough to move it. If two drums are used pulsating concordantly, a figure is obtained precisely like that produced by iron filings in a field of two similar magnetic poles. If the pulsations are discordant, the figure is like that obtained with two dissimilar poles. Three pulsating drums give a figure identical with that produced by three magnetic poles.

A number of interesting conclusions may be drawn from these experiments concerning the nature of electric and magnetic vibrations, but they need to be further confirmed before a positive announcement of them can be justified.

THE CAUSE OF TUBERCULAR DISEASE.

LETTER FROM PROFESSOR TYNDALL TO THE LONDON "TIMES."

ON the 24th of March, 1882, an address of very serious public import was delivered by Dr. Koch before the Physiological Society of Berlin. It touches a question in which we are all at present interested—that of experimental physiology—and I may, therefore, be permitted to give some account of it in the "Times." The address, a copy of which has been courteously sent to me by its author, is entitled "The Etiology of Tubercular Disease." Koch first made himself known by the penetration, skill, and thoroughness of his researches on the contagium of splenic fever. By a process of inoculation and infection he traced this terrible parasite through all its stages of development and through its various modes of action. This masterly investigation caused the young physician to be transferred from a modest country practice, in the neighborhood of Breslau, to the post of Government Adviser in the Imperial Health Department of Berlin.

From this department has lately issued a most important series of investigations on the etiology of infective disorders. Koch's last inquiry deals with a disease which, in point of mortality, stands at the head of them all. If, he says, the seriousness of a malady be measured by the number of its victims, then the most dreaded pests which have hitherto ravaged the world—plague and cholera included—must stand far behind the one now under consideration. Koch makes the startling statement that one seventh of the deaths of the human race are due to tubercular disease, while fully one third of those who die in

active middle age are carried off by the same cause. Prior to Koch it had been placed beyond doubt that the disease was communicable; and the aim of the Berlin physician has been to determine the precise character of the contagium, which previous experiments on inoculation and inhalation had proved to be capable of indefinite transfer and reproduction. He subjected the diseased organs of a great number of men and animals to microscopic examination, and found, in all cases, the tubercles infested with a minute, rod-shaped parasite, which, by means of a special dye, he differentiated from the surrounding tissue. It was, he says, in the highest degree impressive to observe in the center of the tubercle-cell the minute organism which had created it. Transferring directly, by inoculation, the tuberculous matter from diseased animals to healthy ones, he in every instance reproduced the disease. To meet the objection that it was not the parasite itself, but some virus in which it was imbedded in the diseased organ, that was the real contagium, he cultivated his *bacilli* artificially, for long periods of time, and through many successive generations. With a speck of matter, for example, from a tuberculous human lung, he infected a substance prepared, after much trial by himself, with the view of affording nutriment to the parasite. Here he permitted it to grow and multiply. From this new generation he took a minute sample and infected therewith fresh nutritive matter, thus producing another brood. Generation after generation of *bacilli* were developed in this way without the intervention of disease. At the end of the process, which sometimes embraced successive cultivations extending over half a year, the purified *bacilli* were introduced into the circulation of healthy animals of various kinds. In every case inoculation was followed by the reproduction and spread of the parasite, and the generation of the original disease.

Permit me to give a further, though still brief and sketchy, account of Koch's experiments. Of six Guinea-pigs, all in good health, four were inoculated with *bacilli* derived originally from a human lung, which, in fifty-four days, had produced five successive generations. Two of the six animals were not infected. In every one of the infected cases, the Guinea-pig sickened and lost flesh. After thirty-two days one of them died, and after thirty-five days the remaining five were killed and examined. In the Guinea-pig that died, and in the three remaining infected ones, strongly pronounced tubercular disease had set in. Spleen, liver, and lungs were found filled with tubercles; while in the two uninfected animals no trace of the disease was observed. In a second experiment, six out of eight Guinea-pigs were inoculated with cultivated *bacilli*, derived originally from the tuberculous lung of a monkey, bred and rebred for ninety-five days, until eight generations had been produced. Every one of these animals was attacked, while the two uninfected Guinea-pigs remained perfectly healthy. Similar experiments were made with cats, rabbits, rats, mice, and other

animals, and, without exception, it was found that the injection of the parasite into the animal system was followed by decided and, in most cases, virulent tubercular disease.

In the cases thus far mentioned inoculation had been effected in the abdomen. The place of inoculation was afterward changed to the aqueous humor of the eye. Three rabbits received each a speck of *bacillus* culture, derived originally from a human lung affected with pneumonia. Eighty-nine days had been devoted to the culture of the organism. The infected rabbits rapidly lost flesh, and after twenty-five days were killed and examined. The lungs of every one of them were found charged with tubercles. Of three other rabbits, one received an injection of pure blood-serum in the aqueous humor of the eye, while the other two were infected in a similar way, with the same serum, containing *bacilli*, derived originally from a diseased lung, and subjected to ninety-one days' cultivation. After twenty-eight days the rabbits were killed. The one which had received an injection of pure serum was found perfectly healthy, while the lungs of the two others were found overspread with tubercles.

Other experiments are recorded in this admirable essay, from which the weightiest practical conclusions may be drawn. Koch determines the limits of temperature between which the tubercle-*bacillus* can develop and multiply. The minimum temperature he finds to be 86° Fahrenheit, and the maximum 104°. He concludes that, unlike the *bacillus anthracis* of splenic fever, which can flourish freely outside the animal body, in the temperate zone animal warmth is necessary for the propagation of the newly discovered organism. In a vast number of cases, Koch has examined the matter expectorated from the lungs of persons affected with phthisis and found in it swarms of *bacilli*, while in matter expectorated from the lungs of persons not thus afflicted he has never found the organism. The expectorated matter in the former cases was highly infective, nor did drying destroy its virulence. Guinea-pigs infected with expectorated matter which had been kept dry for two, four, and eight weeks respectively were smitten with tubercular disease quite as virulent as that produced by fresh expectoration. Koch points to the grave danger of inhaling air in which particles of the dried sputa of consumptive patients mingles with dust of other kinds.

It would be mere impertinence on my part to draw the obvious moral from these experiments. In no other conceivable way than that pursued by Koch could the true character of the most destructive malady by which humanity is now assailed be determined. And, however noisy the fanaticism of the moment may be, the common sense of Englishmen will not, in the long run, permit it to enact cruelty in the name of tenderness, or to debar us from the light and leading of such investigations as that which is here so imperfectly described.

SKETCH OF CHARLES R. DARWIN, LL. D.

MR. DARWIN died at his home, Down House, near Orpington, England, April 19th. He had been suffering for some time from weakness of the heart, but continued to work till the last. He was taken ill, after having enjoyed an apparent improvement, on the day before his death, with pains in the chest, faintness, and nausea, from which he never recovered.

Mr. Darwin inherited his scientific tastes from two successive generations of ancestors, and has transmitted them to some of his children. His grandfather, Dr. Erasmus Darwin, was a distinguished botanist, and was the author of a poem "The Botanic Garden," the merits of which are decidedly more botanical than poetical, but which has a place in English literature; and of the "Zoönomia, or the Laws of Organic Life," a work in which the theory of development was plainly foreshadowed. His father, Dr. Robert Waring Darwin, was a Fellow of the Royal Society. His grandfather on the mother's side was the celebrated Josiah Wedgwood, whose name is intimately associated with the Wedgwood earthenware.

Charles Robert Darwin was born in Shrewsbury, England, February 12, 1809, and received a preparatory education at the grammar-school of that place, under the head-mastership of Dr. Samuel Butler, author of one of the old standard text-books on geography, and afterward Bishop of Litchfield and Coventry. He entered the University of Edinburgh when sixteen years old, and two years later, in 1827, went to Christ's College, Cambridge, whence he was graduated Bachelor of Arts four years afterward. The most that is known definitely of his special pursuits at these institutions is that at Edinburgh he gave some attention to marine zoölogy, and read his first scientific paper, "On the Movement of the Ova of Frustra" before the Plinian Society, and that at Cambridge he was especially interested in botany.

His Majesty's ships Adventure and Beagle had returned in 1830 from a four years' survey of the coasts of Patagonia and Terra del Fuego. Captain Fitzroy, of the Beagle, had gained so much credit by his efficiency as an officer and the value of the observations he recorded, that he easily obtained a commission to return to the South American waters on another and more extensive exploring expedition. Before going he made a public offer to give up a part of his own cabin to any competent naturalist who would accompany him. Darwin saw the notice, and at once offered his services without salary, on the condition that he should be given the disposition of his collections. He was accepted, and thus obtained, when twenty-two years old, "what would be considered a prize by any naturalist of double his age." The expedition, with Darwin as one of its members, sailed on the 27th of Novem-

ber, 1831, and was gone four years and ten months, during which time it visited Brazil, Patagonia, Chili, Peru, the Galapagos and Society Islands, New Zealand, Australia, Mauritius, St. Helena, and the Cape Verd Islands. The observations taken during this voyage and the previous expedition were published by Captains King and Fitzroy, their commanders, in a voluminous report, to which Mr. Darwin contributed a volume embodying "A Journal of Researches into the Geology and Natural History of the Various Countries visited by his Majesty's Ship Beagle, under the Command of Captain Fitzroy, from 1832 to 1836." Of this work Sir Charles Lyell wrote to the author, in September, 1838, before it was actually published: "I assure you my father is quite enthusiastic about your journal, which he is reading, and he agrees with me that it would have had a great sale if separately published. The other day he told me that he wished to get a copy bound the moment it was out, and send it as a present to Sir William Hooker, who, more than any one, would be delighted with yours. He was disappointed at hearing that it was to be fettered by the other volumes, for, although he should equally buy it, he feared so many of the public would be checked from doing so." The volume was published separately in 1845. The ten years which followed Mr. Darwin's return to England were mainly devoted by him to the publication of the numerous and important results that had been obtained during the voyage. He edited the treatises of Professor Owen, Mr. Waterhouse, Mr. Gould, the Rev. J. Jenyns, and Mr. Bell, on the different groups of vertebrate animals as "The Zoölogy of the Voyage of H. M. S. Beagle"; and he wrote three separate volumes embodying further fruits of his observations than he had given in the "Report," "On the Structure and Distribution of Coral Reefs" (1842); "Geologic Observations on Volcanic Islands" (1844); and "Geological Observations on South America" (1846). Of the first three works, a reviewer of the second edition in "Nature," in 1874, says: "The rising generation of naturalists and geologists have not had, and most probably will never have, such feelings of intellectual pleasure as fell to the lot of the readers of Charles Darwin's book on 'Coral Reefs,' which was offered to science more than thirty years ago. The recent researches into the nature of the deposits of the deep-sea, and the discoveries of bathymetrical zones of water of very different temperatures, are certainly full of vast interest, and will afford the data for the development of many a theory; but the clear exposition of facts, and the bold theory which characterized the book on 'Coral Reefs,' came unexpectedly and with overpowering force of conviction. The natural history of a zoophyte was brought into connection with the grandest phenomena of the globe—with the progressive subsidence of more or less submerged mountains, and with the distribution of volcanic foci." And this reviewer adds that "even at this period of Darwin's life the importance of the struggle for existence had been recognized by him, and had in-

fluenced his thoughts. He remarks that he 'can understand the gradation only as a prolonged struggle against unfavorable conditions.'" The President of the Geological Society has said that, "looking at the general mass of Mr. Darwin's results, I can not help considering his voyage around the world as one of the most important events for geology which has occurred for many years." Professor John W. Judd, noticing the works of this series in a group, said, in 1877, "Students of Mr. Darwin's earlier geological writings must all have been impressed by the powers of minute observation, the acumen in testing, and the skill in grouping data, and the boldness and originality in generalization which distinguished their author; for these characteristics are no less distinguished in the theory of coral reefs than in that of natural selection"; and "these 'Geological Observations' are well worthy to take their place in the long series of the author's contributions to the doctrine of descent side by side with those more widely known works on different departments of zoölogy and botany which have been published subsequently to the 'Origin of Species.'"

His most important work on zoölogy, "A Monograph of the Family Cirripedia," was published by the Ray Society, 1851 to 1853. It gave accurate determinations of every recognized species of the animals known as barnacles and sea-acorns; and was shortly afterward followed by another monograph on the fossil species of the same family, which was brought out by the Philosophical Society. All of these works—each of which was, as the estimates we have quoted indicate, of the first importance in itself, and each of which is a standard to this day—were but as preliminaries to the culminating achievement of Mr. Darwin's life, the exposition of the doctrine of the origin of species and development by natural selection, as given in the series of works on "The Origin of Species by Means of Natural Selection; or, the Preservation of Favored Races in the Struggle for Life" (1859); "The Variations of Plants and Animals under Domestication" (1867), and "The Descent of Man and Selection in Relation to Sex" (1871); and in the numerous special works in which he has made various particular phenomena of animal and vegetable life illustrate and re-enforce his great doctrine. The views expressed and defined in these works, although, now that they have "come of age," they have sensibly and profoundly affected the whole world of thought, were a surprise. Scientific men received them hesitatingly or with incredulity; those who were not scientific with displeasure. Yet they were not wholly novel; for Aristotle, Goethe, Mr. Darwin's grandfather, and others, had suggested similar hypotheses, and Mr. Wallace had independently reached conclusions very like those enunciated by Mr. Darwin. They have had to make their way against the prepossessions of the minds to whom they appealed, and against the prejudices which those prepossessions awakened when they were assailed.

Gradually the theory of descent gained acceptance among the

scientific thinkers of England, with whom the proportion of those ready to deny it grows less from year to year. In Germany it became, in the course of ten years, more or less completely accepted by those best qualified to judge, and was the occasion of the production of a considerable literature of arguments and facts in its favor, without encountering any very serious opposition. In France, the truth of the theory was far less extensively admitted, and it continued to be, for many years, the object of a vigorous and often bitter opposition, the echoes of which have hardly yet died away. A prolonged discussion took place in the French Academy of Sciences relative to the merits of the author of the theory in 1870, when Mr. Darwin was nominated to fill the vacancy in the zoölogical section caused by the death of M. Purkinge. M. Milne-Edwards first spoke in his favor, saying that, while he was himself absolutely opposed to evolutional doctrines, he rendered homage to the value of the special works of Mr. Darwin, especially to the theory of the formation of coral islands. M. Elie de Beaumont added his testimony to the value of this theory, and remarked that Mr. Darwin had done good work which he had spoiled by dangerous and unfounded speculations; he should not be elected until he had renounced them. M. Emile Blanchard was very severe upon Mr. Darwin for an hour, styling him an "intelligent amateur"; and M. Elie de Beaumont interpolated that his work was the "froth of science." M. de Quatrefages replied to M. Blanchard, saying that there were two men included in Mr. Darwin, a naturalist observer and a theoretical thinker: the naturalist is exact, sagacious, and patient; the thinker is original and penetrating, often just, sometimes too rash. That the theory with which his name is connected, that of natural selection, has in it something seductive and plausible, is shown by its having been worked out by such men as Darwin, Wallace, and Naudin, laboring independently and in different paths. If the ideas and the works of Darwin are such as some of his opponents represent, how can they have obtained the support, in less than ten years, of such men as Lyell, Hooker, Huxley, Karl Vogt, Lubbock, Haeckel, Filippi, and Brandt himself, who has just been elected correspondent in opposition to Mr. Darwin? Then, having enumerated Mr. Darwin's works in geology, comprising seven real contributions to the science, and in zoölogy, his works on the origin of species and variation, and particularly his investigations of the strange variations in fowls, pigeons, and rabbits, M. de Quatrefages summed up by saying: "Mr. Darwin is an eminent naturalist, who wishes to remove from science the invocation of the first cause, and to seek the explanation of the natural facts of the organic world in secondary causes, as was done long ago in geology, chemistry, and physics. But he goes no further; and we ought not to judge Darwin by the words of a few disciples who seem never to have read his works. It would be unjust to make him responsible for the exaggerations and

aberrations of those who take refuge under his name." M. Robin made an argument which presents a singular appearance now, in view of the hosts of minute but important facts which Mr. Darwin has showered upon science since it was made, that, in respect of demonstrable facts which he had introduced, there would be a hundred zoölogists who should have precedence over him. If from his publications "we eliminate the views, neither the reality nor falseness of which is demonstrable, and which are therefore not objects of science, there remains to him a share of titles which is inferior to that represented by the well-demonstrated scientific data introduced by M. Bischoff; there remain to him even fewer titles to our suffrages than to any of the *savants* who are placed on an equality with him in our list of presentations." Mr. Darwin was not elected. His name came before the Academy again, on a nomination to be a foreign correspondent, in 1872, and received the same support and the same opposition as two years before. He was rejected—receiving only fifteen votes, to thirty-two cast for Mr. Loewen, of Stockholm. His time came at last to receive the recognition of French men of science. He was elected a corresponding foreign member in the zoölogical section in 1878, by a vote of twenty-six to fourteen, after a rapid change in his favor, and three years after having received a similar recognition from the Imperial Academy of Science of Vienna. On the occasion of his sixty-ninth birthday, in 1877, he received, as a testimonial from Germany, an elegant album, containing the photographs of one hundred and fifty-four men of science in that country, addressed "To the Reformer of Natural History, Charles Darwin," and a similar album containing the photographs of two hundred and seventeen distinguished professors and lovers of science in the Netherlands, accompanied with an account of the progress of opinion in that country with respect to evolution, as a proof which, it expressed, "we are persuaded, can not but afford you some satisfaction that the seeds by you so liberally strewed have also fallen on fertile soil in the Netherlands." Mr. Darwin replied to the latter testimonial modestly, acknowledging his obligations to previous observers of facts, and adding: "I suppose that every worker at science occasionally feels depressed, and doubts whether what he has published has been worth the labor which it has cost him; but for the remaining years of my life, whenever I want cheering, I will look at the portraits of my distinguished co-workers in the field of science, and remember their generous sympathy." In 1877 the University of Cambridge, amid circumstances of great enthusiasm, conferred the degree of LL. D. on him in a Latin oration, in which his work was neatly summarized, and which closed, "Thou, also, who hast so learnedly illustrated the laws of nature, be our doctor of laws." A subscription was afterward inaugurated at Cambridge for the erection of a permanent memorial of him, which it was agreed should be a picture, to be painted by Mr. W. M. Richmond.

Mr. Darwin's later works, besides those which we have already named, which are for the most part monographs embodying facts and researches into the manner in which different functions of animals and plants are developed, include "The Various Contrivances by which Orchids are fertilized by Insects" (1862); "The Movements and Habits of Climbing Plants" (1865); "The Expression of the Emotions in Man and Animals" (1872); "Insectivorous Plants" (1875); "The Effects of Cross and Self Fertilization in the Vegetable Kingdom" (1876); "The Different Forms of Flowers and Plants of the Same Species" (1877); "The Power of Movement in Plants" (1881); "The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits" (1882). All of these works have been received with interest by the public, and have been fully noticed in our pages. The works which have been called forth by the influence of Mr. Darwin's writings are catalogued in a German pamphlet of thirty-six octavo pages, containing the names of three hundred and twelve authors.

Mr. Darwin was subject to frequent sudden attacks of illness which laid him prostrate for days together. The periods of convalescence were made useful for observations requiring almost constant attention; and such observations, made in the sick-room, are referred to in his "Climbing Plants." His tastes were almost wholly scientific. For sculpture or pottery, or even for drawing, except as an aid to botanical and zoölogical pursuits, he cared very little, his collection of pictures being confined to a portrait of old Dr. Darwin and one of Josiah Wedgwood, hanging in his dining-room, and sketches of Sir Joseph Hooker and Professor Huxley in his study.

Commenting on Mr. Darwin's methods of investigation and presentation, "Nature" remarks in a review of one of his books, that, in turning over its pages, "one is almost distracted from the intrinsic interest of the facts and speculations by the sagacity with which the research is carried on, and the skill with which the results are marshaled for our information. It is peculiarly worthy of notice . . . how the reader is allowed, in studying Mr. Darwin's pages, to form his own hypothesis in explanation of the facts, only to be compelled, in due course, as the narrative proceeds, to admit that such hypotheses are utterly untenable." Scientific candor is mentioned as one of his prominent qualities by Mr. J. W. Judd, who says that, "like his teacher and friend, the late Sir Charles Lyell, he never forgets in his discussions to look at all sides of the questions before him, and to give the fullest expression and weight, alike to the difficulties which he himself detects, and to arguments which opponents may have advanced." This quality is well illustrated in the successive editions of the "Origin of Species," where the author's changes or modifications of views in particular points are frequently acknowledged and recorded.

EDITOR'S TABLE.

CHARLES ROBERT DARWIN.

THE present year will be memorable in the history of science as bringing to a close the labors of two illustrious scientific thinkers—one, perhaps, the most eminent man of science in America, Dr. John William Draper, and the other probably the most celebrated scientific man of the world at the present time, Dr. Charles Robert Darwin. Both men had accomplished their work, the former dying at the age of seventy-one, and the latter at the age of seventy-three; and it is remarkable that both were among the most distinguished representatives of the same school of progressive scientific thought. Their names will be for ever associated with that great revolution of ideas for which all modern science has prepared, but which has been accomplished only within the present generation. Both men made large and important contributions, by observation and experiment, to the departments of science which they respectively cultivated, but they will be measured in future chiefly by the bearing of their work upon the great intellectual movement of the period.

Everybody knows what we mean in speaking of the movement of thought with which the names of Draper and Darwin are identified; and which we have referred to as a revolution of ideas already accomplished. One of its leading aspects is the application of the scientific method to the phenomena of life in order to explain their changes by natural causes. Mr. Darwin's name has been so closely associated with this extension of scientific method to cover the origin of the diversities of living beings upon earth that he has come to be a representative of the idea; while the term "Darwinism" has been vaguely employed to stand for the doctrine. The twenty volumes of "The Popular Science Monthly" bear uniform and abundant record that "Darwinism" has been generally accepted as true in the world of science for the last ten years. But there is a sharper test of the change of opinion that has taken place than any affirmation regarding the verdicts of scientific men. At its earliest promulgation "Darwinism" was denounced by the whole body of religious authorities as false and execrable. There was never such unanimity in the pulpit as was displayed in cursing the new apostle of the doctrine of man's descent from an ancestry of inferior animals. The devil got a considerable respite while the batteries were all being turned upon Darwin as the arch-enemy and subverter of all religion. But, as the movement of ideas went on all the same, common sense began to assert itself in various quarters, so that there has latterly been more temperateness of condemnation, and even a readiness to accept the long-detested doctrine as probably true, and by no means so bad as it at first seemed. And, now that Darwin is dead, there is a universal burst of admiration for the man, accompanied by abundant admissions that his ideas are true; and he is laid in Westminster Abbey alongside of Newton, while the most eminent preachers of London agree in declaring that there has been nothing in his teaching that is not wholly consistent with the soundest Christian belief. Canon Liddon, of St. Paul's, author of "The Divinity of our Lord and Saviour Jesus Christ," is reported to have said in a sermon that "Mr. Darwin's theories are not necessarily hostile to the fundamental truths of religion"; and Canon Barry, author of "Orthodox Commentaries on Portions of the Bi-

ble," declared that "the doctrine of evolution lent itself as readily to promises of God as less complete explanations of the universe."

To explain the world-wide fame of Mr. Darwin and the expressions of high appreciation that have been elicited by his death, several circumstances must be taken into account. In the first place, his pre-eminence as a naturalist is not for a moment to be questioned. He had a genius for investigation in this field, as is shown by the immense amount of valuable and original work that he has accomplished. As an accurate and indefatigable observer, of keen insight, and equally fertile and skillful in his experimental devices to bring out the secrets of Nature, he was probably without a rival. Descended from a race of naturalists, he seemed to have a constitutional intuition for penetrating the mysteries of living beings, and detecting subtilties that had eluded previous observers. Patient, industrious, and concentrated upon his work, he has enriched natural history with a multitude of new facts, which will make his name an authority for all future time.

But Mr. Darwin was more than a mere observer and accumulator of facts; he was a man of ideas capable of methodizing his observations and making them tributary to the progress of theoretical views. He found the problem of the origin of the diversities of living beings unsettled, he subordinated all his researches to its solution, and he put forth a theory upon the subject that has made him famous. This was the principle of natural selection, called also the survival of the fittest, and it was elaborated with a wealth of illustration that rapidly commended it to the acceptance of the scientific world. In a nutshell it is this: There is a law of heredity, or descent of traits, from generation to generation, in the kingdom of organic life—a law under which "like produces like." But there is also a law of variation by which like always produces the slightly unlike—a modification from generation to generation, and adaptation to ever-changing conditions. At the same time the rate of multiplication gives rise to a destructive struggle for existence, in which multitudes perish and but comparatively few survive, while the survivors are those best fitted to the new conditions. In this way new characters are strengthened and developed, and old traits are weakened and disappear, so that the progress of life is at the same time a slow transformation, in which at first new varieties and then new species gradually arise by minute increments of change. Thus the diversities among living creatures are accounted for by the operation of natural agencies.

But, besides the intrinsic character of his work, the traits of the man were eminently calculated to produce the most favorable impression. He was not a controversialist, and, instead of going roughly athwart men's prejudices, he was kindly, considerate, and conciliatory in all his writings. He was also modest and eminently candid and fair-minded, always seeking to do justice to the views of his opponents. Men felt that his supreme object was simply to get at the truth. For this he labored incessantly and untiringly, and thus won the respect of all who can appreciate sincerity of aim and elevation of purpose. Added to this he was a very genial and pleasant man in his personal relations, and most highly regarded by those who were honored with his acquaintance and friendship.

But still other elements must be taken into account in explaining the extent of his popularity. He was a remarkably fortunate man. We refer not so much to his easy circumstances, which gave him command of resources and allowed full consecration to a life of study; but we mean that he came at a great crisis of thought, when a lead-

er was wanted in a comprehensive scientific field. It was his happy fortune to avail himself of a previous advance of biological inquiry, which was much greater than is generally supposed. Mr. Darwin has himself fully pointed out to what various extents his idea of natural selection had been discerned by preceding naturalists. It was a discovery all ready to be made, and how inevitably it grew out of the state of knowledge that had been attained, and how imminent it was in the thought of the time, is shown by the fact that he was compelled to publish on the subject earlier than he had intended, to prevent being anticipated by Mr. Alfred Russel Wallace, who had already arrived at and worked out the same principle. It was fortunate for the fame of Mr. Darwin that Mr. Wallace so gracefully and generously stepped aside, and surrendered to him the full leadership of the new biological reform.

Nor is it to be forgotten, in enumerating the causes that have conspired to give such prominence to the name and fame of Darwin, that his subject was one of intense and universal interest. No matter how unpalatable were the theories proposed, everybody was concerned with questions of the origin of life, because they involved explanations of human origin. Whence we came has always been a riddle which there has been an irrepressible curiosity to solve. Mr. Darwin's explanation came in the name of science, and, apparently involving but a single principle of such simplicity and familiar illustration that everybody could understand it, his little book was sought for and read with avidity by all classes. And yet, in the nature of things, it was impossible that the work should be generally understood with any thoroughness. It dealt with an order of ideas for which our higher education made no preparation, so that the college graduate was little better equipped than the uneducated country farmer to read intelligently and appreciatingly the argument of the "Origin of Species." There was, consequently, a great deal of popular confusion and misapprehension as to what Mr. Darwin had really done, and which naturally led to erroneous and even extravagant claims as to the nature and scope of his work. To those who were not well instructed he came to be regarded as the creator of an epoch and the originator of the whole scheme of ideas connected with his investigations. We see this in the tendency to attribute to Mr. Darwin the fatherhood of the law of evolution, and to identify evolution with Darwinism. He contributed to that universal law a most important principle, but he was neither its founder nor did he ever attempt anything like its general exposition. That great doctrine had been overwhelmingly proved, had been resolved into its forces, formulated, and extensively applied to the reorganization of scientific knowledge, before Mr. Darwin had ever published a word upon the subject. He has done noble work, and his position is for ever assured among the greatest in science; and, if circumstances have tended to favor some exaggeration of his real claims, we may leave to time the correction of imperfect judgments, and the equitable award of all honors among those to whom honors are due.

A VERY MODERN REPROACH.

COMMENTING, two months ago, upon Goldwin Smith's article attacking scientific ethics, we pointed out the extensive co-existence of supernatural beliefs with a lax morality. The "Christian Union," under the title of "A Very Ancient Reproach," charges "The Popular Science Review" with reviving a stale old accusation of Thomas Paine. It, moreover, attempts to confound us with "History," and offers a quotation from Gibbon, declaring that through conversions by the early Church "the

most abandoned sinners" in many cases became "the most eminent saints." The "Union" then proceeds to remark: "If 'The Popular Science Monthly' desires further information as to the actual effect which evangelical religion has produced on the morals of the community, it will be found in abundance in Lecky's 'History of European Morals,' in the same author's 'History of England in the Eighteenth Century,' and in Professor Draper's 'History of the Intellectual Development of Europe,' and none of these authors can be accused of being eulogists of Christianity. We leave the 'Review' to settle it with Gibbon which horn of the dilemma it will accept."

We have no issue with Lecky or Draper, and nothing to settle with Gibbon. If we had no other source of information respecting the relations of faith and morals as manifested in human conduct, than what was written a hundred years ago about what took place sixteen hundred years earlier, it would be different; but the illustrations of the relation of religious belief to ethical practice are too clear, familiar, and impressive all around us to make this course necessary. On living questions we prefer living authorities, and judgments based upon immediate observation and experience, to historic inferences regarding what took place at remote periods. Accordingly, we value the testimony of the editor of the "Christian Union" higher than even that of Gibbon, while his record is far more to the point. The article entitled "A Very Ancient Reproach" is immediately followed by another which serves as an instructive comment upon it by showing that the "reproach" is also both very modern and very real. Its title is "A Missouri Saint," and the editor writes upon the subject with an openness which "The Popular Science Monthly" has never emulated. He says:

St. James—St. Jesse James—is the latest contribution of America to the noble army of saints and martyrs.—

Death seems to settle all accounts; and no sooner was this murderous villain dead, than the whole community set to work with extraordinary unanimity to canonize him. His funeral was an ovation; the attendant throng crowded the Baptist church, "where he was converted in 1866"—heavens! what sort of a man would he have been if he had not been converted?—the sheriff and under-sheriff acted among the pall-bearers; the services were opened with the hymn "What a friend we have in Jesus!" the officiating ministers comforted the stricken community with extracts from the plaints of Job and David, and with a comforting discourse on Christ's forbearance and forgiveness of sins; and, finally, the procession to the grave was one of immense proportions.

Out upon such a religion as this! If a Dr. Thomas intimates that there may be perhaps a probation in another world for those who seem to have had no true probation in this, he is turned out of the fellowship of the church as a heretic. If a Mr. Jones and a Mr. Martin send a freebooter and a life-long robber and murderer straight to heaven in a chariot of fire without as much as a baptismal bath by the way, will any church call them to account for their falseness to the law of God and the sacredness of morality? We shall see.

Excellent, certainly! But, if exactly the same sentiments, only pitched in a lower key of indignation, appear in "The Popular Science Monthly," we are accused of reviving the obsolete reproaches of infidelity, and the "Christian Advocate" breaks into a pious diatribe about "Sugar-coated Poison."

The view of the "Christian Union" is well confirmed by "The Nation," as follows:

James's relations to the Church, too, had a curiously mediæval flavor about them. He was the son of a Baptist minister, but his career apparently did not strike his mother, or any of his family or neighbors, as inconsistent with the possession of a stock of fundamental and ineradicable piety. When he died, she rejoiced in the thought that he had gone to heaven. Two Baptist ministers performed the funeral services, and a vast concourse of friends, including the sheriff, who was deeply affected, followed the remains to the grave, not sorrowing, apparently, as those

who are without hope. In fact, the James territory, which includes the adjacent corners of four States, is a region which seems closely to resemble in its religious and moral condition a Frankish kingdom in Gaul in the sixth century. Every one knows how very early in the history of the Church the tendency to make faith take the place of right-living began to show itself. St. James had to warn the very first generation of Christians that pure religion and undefiled consisted not in sound belief, but in good deeds. The difficulty of making people show their faith by their works has beset Christianity ever since. Barbarians rapidly accepted the Christian dogmas, and took eagerly to the rites and ceremonies of the Church, but they never were quite ready to accept its views about behavior. Gregory of Tours, in his most instructive chronicle, tells some very grotesque stories of the difficulties which the bishops had in Gaul in his day in refusing the communion to notorious evil livers. One Frankish chief—a great robber and cut-throat—insisted on having it administered to him, and the bishop had to let him have it, in order to save life, for he threatened to kill all the other communicants if he was not allowed to partake also. The comfort the Italian and Greek brigands find in the external observances of their creed, while committing the most atrocious crimes, is now an old story. A skeptical or agnostic robber is in fact unknown in Eastern or Southern Europe.

The devout brigands all belong to the Catholic or Greek Church, which has always greatly exalted the value of external worship and pious credulity, and thus furnishes only too much temptation to those who are ready to believe without limitation for the purpose of postponing any change in their habits. The Protestant Church has been much more exacting in the matter of conduct, and in fact has afforded in its teaching but few of the refuges for easy-going sinners which its great rival provides so plentifully. But the fight between faith and right-living nevertheless rages within its borders unceasingly, and not always to the advantage of the latter. It is not only in the James district in Missouri that one comes on the strange compromises by which a certain external devoutness is made to atone to the conscience not only for spiritual coldness, but for long and persistent violations of the fundamental rules of morality. Startling as are these revelations about the state of society in that part of the country, they are hardly more startling, everything considered, than the frequency with which our defaulters and embezzlers in this part of the world prove to have been vestrymen, deacons, Sunday-school superintendents, and prominent church-members during long years of delinquency and perfidy.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES. No. XL.

Myth and Science. An Essay by Tito Vignoli. D. Appleton & Co. Pp. 372. Price, $1.50.

Though an opportune and much-needed book upon a subject that is exciting wide attention in the higher circles of inquiry, yet this treatise is of a much graver character than its title might imply to those familiar with current mythic literature. It is not a book of old fairy tales nor of the mythological legends of different peoples, but it is a compact disquisition on the origin and nature of the common mythical element manifested by all grades of intelligence. It is a philosophical essay, and some critics declare it to be as hard as metaphysics, which is saying a good deal, because the book is far more interesting than metaphysics.

A leading element of interest in this volume comes from the point of view taken by the author in the investigation. He assumes evolution without any reserve, and declares that "it is evident, at least to those who do not cling absolutely to old traditions, that man is evolved from the animal kingdom." It is true that Mr. Max Müller, the grammarian of mythical romance, not long ago republished his prophecy that "the idea of a humanity emerging slowly from the depths of animal brutality can never be maintained again in our century." But it certainly does not look much as if the doctrine were at present thus discredited. Mr. Darwin, its great apostle, was yesterday entombed in Westminster Abbey with the singing of an anthem composed expressly for the occasion, in the presence of the best talent of the country and a formal deputation from the University of Oxford and representatives from learned societies, the import of the whole being that "Darwin's work was at length claimed by the nation as its own," while, by the verdict of Europe, the author of the "Descent of Man" was pronounced to be the greatest scientist of his age. At

any rate, Mr. Vignoli has the science of the world and probably the truth of the case on his side. But, if man was developed from the lower animals, he has derived his psychical faculties, as well as his bodily organism, from his inferior ancestors; and, although he has left them by a wide gap, they are still parts of a series with so much remaining in common that the higher can only be interpreted in derivative connection with the lower. On this view the mythical element, as considered by our author, begins with the lower animals, and comparative psychology is appealed to, with many special experiments, to show that animals endow the objects around them with a consciousness like their own. Man, in his early stages, does a similar thing by "animating" the forces and objects of nature, and filling the world with mythical personalities. This process goes on, according to Mr. Vignoli, with the advance of intelligence, so that science, instead of ending myths, only modifies them. Man "personifies all phenomena, first vaguely projecting himself into them, and then exercising a distinct purpose of anthropomorphism until, in this way, he has gradually modified the world according to his own image."

In his opening chapter on the ideas and sources of myths, Mr. Vignoli thus presents the point of view from which he considers the subject:

> We do not propose to consider in this treatise the myths peculiar to one people nor to one race; we do not seek to estimate the intrinsic value of myths at the time when they were already developed among various peoples and constituted into an Olympus or special religion; we do not wish to determine the special and historical cause of their manifestations in the life of any one people, since we now refrain from entering on the field of comparative mythology. It is the scope and object of our modest researches to trace the strictly primitive origin of the human myths as a whole; to reach the ultimate fact, and the causes of this fact, whence myth in its necessary and universal form is evolved and has its origin.
>
> We must, therefore, seek to discover whether, in addition to the various causes assigned for myth in earlier ages, and still more in modern times, by our great philologists, ethnologists, and philosophers of every school—causes which are for the most part extrinsic—there be not a reason more deeply seated in our nature, which is first manifested as a necessary and spontaneous function of the intelligence, and which is, therefore, intrinsic and inevitable.
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> In this case myth will appear to us, not as an accident in the life of primitive peoples varying in intensity and extent, not as a vague conception of things due to the erroneous interpretation of words and phrases, nor again as the fanciful creation of ignorant minds; but it will appear to be a special faculty of the human mind, inspired by emotions which accompany and animate its products. Since this innate faculty of myth is indigenous and common to all men, it will not only be the portion of all peoples, but of each individual in every age, in every race, whatever may be their respective condition.
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> Myth, therefore, will not be resolved by us into a manifestation of an obsolete age, or of peoples still in a barbarous and savage state, nor as part of the cycle through which nations and individuals have respectively passed or have nearly passed; but it remains to this day; in spite of the prevailing civilization which has greatly increased and is still increasing, it still persists as a mode of physical and intellectual force in the organic elements which constitute it.

Easy Lessons in Science. Edited by Professor W. F. Barrett. Light. By Mrs. W. Awdry. Pp 114. Heat. By C. W. Martineau. Pp. 136. Macmillan & Co.

Verily, verily, if the children of this generation do not grow wise in science, it will not be for lack of elementary books for the purpose. "Rudimentary Lessons," "Elementary Lessons," "Simple Lessons," "Easy Lessons," and "Primers" innumerable, separate and in groups, edited by one book-maker and written by others, are already multiplied on every hand, and are increasing more rapidly than ever. They must be purchased, or they would not continue to be made; and, if purchased, they are probably read and used—so that, on the whole, we may assume that the result is good. But one thing is certain—the excellence of these books is in no relation to their numbers, nor is it easy to discern much if any improvement in the successive series. They are all lesson-books with abundant pictures to be learned in the old-fashioned way in the school-room. There is some effort at cheapening the means of experiment for scientific illustration, and, in so far as this promotes demonstration, the effect is undoubtedly beneficial. But these little manuals generally display but a very limited acquaintance with the minds of the young, and they are all conformed to the common type of books of information to be obtained by the regular old process of reading and lesson-learning.

The two volumes before us on "Light" and "Heat" are of the usual character. The name of Professor Barrett as editor may be taken as a guarantee that the volumes are accurate in their statements, but we see no evidence that the editorship goes any further. They seem to be ordinary text-books merely reduced in dimensions. Good teachers might use them, we think, with good effect, but good teachers are few, and the best teachers are independent of their books. On the other hand, bad teachers are innumerable—they are the rule, and the real question about primary books is how they work in the hands of incompetent teachers. The best books in these circumstances are those that favor the self-education of the pupil, and release him from the over-meddling of stupid instructors. The books before us, it is needless to say, are not of that order.

Die chemische Ursache des Lebens theoretisch und experimentell nachgewiesen. (The Chemical Cause of Life theoretically and experimentally demonstrated.) By Oscar Loew and Thomas Bokorny, of Munich. Munich, Bavaria. 1881. Pp. 60, with a Colored Plate.

Since the first synthesis of an organic body, urea, was made by Wöhler in 1828, say the authors of this treatise, vital force has been regarded as the result of chemical and physical processes. This has been accepted as satisfactory till the present time, notwithstanding it has been necessary to admit, on a closer consideration, that a clearer definition of the chemical activity by which living protoplasm is governed would be hailed as a very desirable step of progress. The idea that there was a chemical difference between dead and living protoplasm never found expression till 1875, and nearly all physiologists still hold the view that a complete chemical identity exists between them, notwithstanding that it would be hardly possible to explain the cause of life if this were the case. E. Pflüger was the first to assert, in 1875, in a paper on physiological combustion in living organisms, that a chemical difference must necessarily exist between living and dead protoplasm. One of the authors of this treatise, in verifying an hypothesis he has proposed on the formation of albumen, met with a number of unaltered Aldehyde groups which stood in close relations with the Amidon groups, and immediately conceived the idea that the source of the vital movement in protoplasm was to be sought in the Aldehyde groups with their intense atomic movements, and the origin of death in the passage of the Aldehyde groups into Amidon groups. Shortly afterward both the authors succeeded in demonstrating the real existence of Aldehyde groups in living plasma. The present monograph gives a full and connected account of their experiments, and of the verifications of them.

The Oyster Industry. By Ernest Ingersoll. Washington: Government Printing-Office. Pp. 251, with Forty-two Plates.

The present monograph is a part of a series on "The History and Present Condition of the Fishery Industries," which is in course of publication under the direction of the United States Fish Commission, in connection with the census. The arrangement of the main part of the work is geographical, beginning with the maritime provinces of Canada, and passing, with copious accounts of the culture and trade in oysters at all important points on the Atlantic coast, to the Gulf of Mexico and the Pacific coast. Chapters follow on the utilization of oyster-shells, and the natural history of the oyster, with notices of the fatalities to which it is subjected. "An Oysterman's Dictionary" offers an entertaining as well as informing collection of phrases and words descriptive of mollusks and other invertebrates of the Atlantic coast. Statistical tables are given in the final chapter.

A Monograph of the Seal-Islands of Alaska. By Henry W. Elliott. Washington: Government Printing-Office. Pp. 176, with Two Maps.

The fur-seal was very often mentioned in the discussions that took place during the negotiations for the acquisition of Alaska, but very little was known of it, and it was hardly represented in the best zoölogical collections. The author of this monograph became interested in the subject, and in 1872, by the joint action of the Secretary of the Treasury and Professor Baird, was

enabled to visit the Pribylov Islands and study the life and habits of the animals. The notes, surveys, and hypotheses here presented are founded on his personal observations in the seal-rookeries of St. Paul and St. George, during the seasons of 1872, 1873, 1874, and 1876. They "were obtained through long days and nights of consecutive observation, from the beginning to the close of each seal season," and cover, by actual surveys, the entire ground occupied by these animals.

The Areas of the United States, the Several States and Territories, and their Counties. By Henry Gannett, E. M., Geographer and Special Agent of the Tenth Census. Washington: Government Printing-Office. Pp. 20, with Map.

The question, "What constitutes the area of the United States?" is by no means a simple one, but involves other questions of including or leaving out inlets, and the measurement of numerous gores. For the purpose of this work the main area was procured by summing up the square degrees, and the areas of the fractions of square degrees were computed after direct measurement, with scales on the maps of the Coast, Lake, and Mexican Boundary Commission surveys. The whole contour of the country is thus given by surveys whose accuracy is unquestioned, except as to the part between the Lake of the Woods and Lake Superior, and a part of the eastern boundary of Maine, of which exact surveys have not been made. The same principles were observed in computing the areas of States and counties, where, however, boundary surveys are often not so accurate as they should be.

Statistics of the Production of the Precious Metals in the United States. By Clarence King, Special Agent of the Census. Washington: Government Printing-Office. Pp. 94, with Six Plates.

This statistical statement is offered in advance of the author's report on the production of the precious metals, of which it will form the concluding chapter, on account of its immediate interest to legislators, financiers, and metallists. It consists almost wholly of statistics, presented in a full and clear manner.

Annual Report of the Chief Signal-Officer of the Army to the Secretary of War, for the Year 1881. Washington City. Pp. 86.

The Signal Service continues to manifest its value, particularly in the meteorological department. The present officer, General Hazen, has endeavored to bring it into active sympathy and co-operation with men of science; and it enjoys the assistance of an advisory committee of the National Academy of Sciences. The work of the year has been marked by advance in nearly every department, among the evidences of which we notice the establishment of a permanent school of instruction at Fort Myer, Virginia; the extension of forecasts to periods of more than twenty-four hours; the forecasts of "northers" for the interior plateau; the extension of the special frost-warning to the fruit interests; the organization of a service for the special benefit of the cotton interest; arrangements for original investigation in atmospheric electricity, in anemometry and in actinometry; and in the last subject, especially with reference to the importance of solar radiation in agriculture, and the absorption of the sun's heat by the atmosphere; the publication of special professional papers; the offering of prizes for essays on meteorological subjects; the organization of State weather services; co-operation in work in the Arctic regions; arrangements for organizing a Pacific coast weather service; and a large increase of telegraphic weather service, without additional expense to the United States. The popular confidence and support of the bureau, General Hazen says, have never been impaired, and the scope of its usefulness increases with each year.

The Constants of Nature, Part V.: A Recalculation of the Atomic Weights. By Frank Wigglesworth Clarke, S. B., Professor of Chemistry and Physics in the University of Cincinnati. Washington: Smithsonian Institution. Pp. 279.

This work and Professor George F. Becker's "Digest" of the investigations of "Atomic Weight Determinations, published since 1814," which forms Part IV of the series of "Constants," are complementary to each other. Professor Clarke began his investigations in 1877, for the purpose of

revising the determinations of the atomic weights of all the elements. He does not claim that any of the results he has reached are final, but admits that each one of them is liable to repeated corrections. The real value of the work, he believes, lies in another direction; the data have been brought together and reduced to a common standard, and the probable error has been determined for each series of figures. Thus the ground is cleared, in a measure, for future experimenters.

The Chemistry of Cooking and Cleaning: A Manual for Housekeepers. By Ellen H. Richards, Instructor in Chemistry, Woman's Laboratory, Massachusetts Institute of Technology. Boston: Estes & Lauriat. Pp. 90. Price, $1.

We are glad to see such a book by such an author from such a place. A lady engaged in teaching practical chemistry in an institute of technology, and applying her science to the art of improving domestic life, affords an example of the fitness of things which is seen much too rarely. To the eye of a stupid public opinion, cooking and cleaning are very vulgar things—the operations of menials and scullions. But to the eye of science they are most interesting processes, tasking thought to master them, giving pleasure in understanding them, and valuable benefit in applying them. To the eye of ignorance, however cultivated, there is nothing about cooking and cleaning that is worthy of respect, and they are therefore left to the incompetent, who give us bad work; but, if they were better understood, practice would be improved, and we should have more wholesome cookery and more perfect cleanliness.

Mrs. Richards's neat little *brochure* is a contribution to domestic education which, though too slight, will be well appreciated. It is not an attempt to compress a great deal of information in a small compass, but to make the subject clear as far as it is treated. Her "Chemistry of Cooking" is at the same time a course of brief lessons in chemistry; that is, enough of the science is thoroughly explained to make its applications intelligible. We cordially commend it as an excellent beginning in a direction that must in future be more carefully and thoroughly pursued.

The Geological and Natural History Survey of Minnesota. Ninth Annual Report, for the Year 1880. By N. H. Winchell, State Geologist. St. Peter, Minnesota. Pp. 392, with Six Plates.

The work of the year covered by this report consisted chiefly of the arrangement for the museum of the crystalline rocks gathered during the previous seasons in the northern part of the State, including the cupriferous series; determinations in paleontology; examinations of building-stones; the study of the hydrology and water-powers; field work in the southwestern part of the State; and the examination of the "Lake region" of the center, with reference to hydrology and the distribution of forest-trees.

La Lumière Électrique; son Histoire, sa Production, et son Emploi. (The Electric Light; its History, Production, and Employment.) By Em. Alglave and J. Boulard. Paris.

The authors have taken advantage of the revelations which the recent International Electrical Exposition at Paris afforded of the extent to which electrical force has been developed as a working power, and the variety of purposes to which it has been practically applied, to prepare this elegant work, showing what has been done in that direction, when, and how. The large mass of material which they had to dispose of has been divided among six books, in the first of which is reviewed the history of artificial illumination, and the different phases through which it has passed from the dimly tempered darkness of the ancients, with their rude oil-lamps, through the stages of tallow, sperm, and stearine candles, and the improved lamps of modern days, to the beginnings of the electric light. The second book treats of voltaic or arc lights, the manner in which the arc is produced, the fabrication of the carbons, and the mechanism of the regulating apparatus, and furnishes descriptions of the different lights of this class. The third book is devoted to incandescent lamps, and includes descriptions of the Edison, Swann, Lane Fox, and Maxim lamps. In the fourth book the different kinds of apparatus for generating the electric current, and in the fifth book the several systems for securing its distribution and division, are described;

and the sixth book comprises accounts of the applications that have been made of the electric light in light-houses, war, navigation, in industry, the arts, and commerce, its installation in mines and excavations, railroad-stations, warehouses, and even in agricultural operations. All of these accounts are profusely illustrated with clear representations of the machinery and apparatus described, with a few landscapes electrically lighted. The authors have also given much information concerning the cost of establishing and maintaining the electric light for these several purposes. The work is thus not only one to be read, but also one that may be profitably consulted for practical purposes.

Bi-Monetism: The Money of Commerce and the Money of the State. By Joseph Stringham. Oshkosh, Wisconsin. Pp. 64.

This pamphlet embodies the results of an inquiry which the author has made into the relations of the two moneys to each other, and into the utility of gold, silver, and paper as materials for money. He concludes that gold is the sole money of commerce, and will continue to be so as long as present commercial customs continue, but that the demand within the several States for paper or silver tokens for use in internal business is sufficient to absorb all the silver, and raise it to its coin value in gold, and keep it there. Silver, if its use for such a purpose should become general in the states of Europe and America, might thus eventually gain a recognized place as money in commerce, but not otherwise; while, under existing circumstances, "silver or any other metal could not be coined at its commercial value in gold without subjecting the coinage to frequent changes."

Guides for Science Teaching. The Oyster, Clam, and other Common Mollusks. By Alpheus Hyatt. With Plates. Pp. 65. Common Minerals and Rocks. By William O. Crosby. Pp. 130. Boston: Ginn, Heath & Co.

We noticed several months ago some volumes of a series of small hand-books published under the supervision of the Boston Society of Natural History, which were designed as aids to teachers wishing to instruct their pupils in branches of that department, but not to be used as text-books. We notice in addition to the works we then named the two whose titles stand at the head of this article. The manual on mollusks is fully illustrated with excellent plates, and Mr. Hyatt is strong in insisting that teachers can not use any text-book as a basis of good instruction, but must lead children to see for themselves. The system of classification set forth in Mr. Crosby's book on minerals is practically illustrated and exemplified in the arrangement of collections in the museum of the society.

The New Ethics: An Essay on the Moral Law of Use. By Frank Sewall. New York: G. P. Putnam's Sons. Pp. 61.

Mr. Sewall regards ethics as appertaining to the will rather than to the intellect; and suggests that it may be considered as a kind of moral æsthetics, or "æsthetics on the moral plane," and defined as a science of taste that treats of the will of man as subject to sensations of pleasure and of pain from moral objects presented to it, and capable of being affected and modified by them. The object of moral education is to adapt man to the moral law of the universe, which, assuming that it is real, may be expressed as the law of use, or of service, "but the law of mutual service, not the service of self." The author has no confidence in intellectual culture as an element of moral progress.

Proceedings of the Boston Society of Natural History. Vol. XX, Part IV, January, 1880–April, 1880. Pp. 169; Vol. XXI, Part I, May, 1880–December, 1880. Pp. 112. Boston: Published by the Society.

The papers of most general interest in the former of these two volumes are the notice of the death of Dr. Thomas M. Brewer, by President Bouvé; and the review of Professor Brewer's scientific labors, by Mr. J. A. Allen. The other volume contains notices of Mr. Bouvé's withdrawal from the presidency of the society, and of the deaths of Dr. C. T. Jackson, Count Pourtalès, Mr. L. S. Burbank, and Mr. George D. Smith. Many of the special papers, which concern

a wide variety of subjects in natural history, geology, physics, and archæology, have been noticed from time to time in "The Popular Science Monthly." Mr. S. H. Scudder, the new president of the society, defines its aim in his inaugural address as distinctively educational; and with this view it restricts its museum to the collection and exhibition of such objects as can be put directly to public use; furnishes direct instruction by lectures, lesson and guide books, to those who have in charge the education of youth; and is working for the introduction and retention of the study of nature in the public schools.

How to make the Best of Life. By J. Mortimer Granville, M. D. Pp. 96. Boston: S. E. Cassino. Price, 50 cents.

This little volume has been added to Dr. Granville's excellent series of small books on the mental phases of personal hygiene. They are all devoted to the conditions of mental health, and to the care of the mind under the strain and exposure of neglect, overwork, bad habits, etc. The present volume is full of miscellaneous suggestions and practical precautions in the conduct of every-day life that, if followed, will be certain to guard against trouble and increase the enjoyment of health. Dr. Granville has improved the literary form of his work as he went on, so that this last part is written in a clearer and simpler style than those which preceded it.

Report on Diphtheria. By Franklin Staples, M. D., Winona. Pp. 44.

The report includes the facts gathered by the State Board of Health respecting the prevalence of diphtheria in the State of Minnesota during two years, from November, 1878, to November, 1880. It embodies the substance of replies received from the several counties of the State in answer to inquiries sent out by the board respecting the prevalence or non-prevalence of the disease, its forms and degree of malignancy, the apparent causes and means of propagation (with express attention to the relations of the disease to water-supply and sanitary surroundings), and the means employed for its prevention. The facts collected, which are given as they were sent up, form a mass of valuable material to aid in the study of the malady. By this study the board say in the report: "We have been able to confirm many points of doctrine now generally understood concerning this disease, and, by observing its behavior on our soil, in our climate, and among the people of the various nationalities of our State, we have been able to arrive at some conclusions as to the kind of sanitary work demanded." These conclusions are given, and are not essentially different from those that have been agreed upon by sanitarians generally.

The Use of Tobacco. By J. I. D. Hinds, Ph. D., Professor of Chemistry in Cumberland University, Lebanon, Tennessee. Cumberland Presbyterian Publishing House. Pp. 138. Price, 75 cents.

This little work presents a view of the subject adapted to popular comprehension, with arguments against the use of tobacco based chiefly on economical, hygienic, and moral grounds, which are designed to reach the public.

The Temple Rebuilt: A Poem. By Frederick R. Abbe. Boston: D. Lothrop & Co. Pp. 251. Price, $1.25.

By the "temple" the author typifies the soul of man, which has been cast into ruins by sin, and is rebuilt on the new foundation of the plan of salvation as laid down by Christ, by the Christian virtues and graces serving as builders, and using prayer and good works as their implements.

Incandescent Electric Lights, with Particular Reference to the Edison Lamps at the Paris Exhibition. By Compte Th. du Moncel and William Henry Preece. With other Papers. New York: D. Van Nostrand. Pp. 176. Price, 50 cents.

A volume of "Van Nostrand's Science Series." It has been called out by the public interest in the growth of the Edison and other systems for maintaining a steady electric light of low intensity. Besides the paper of Compte du Moncel and the address of Mr. Preece, which give the title to the book, the volume contains articles on "The Economy of the Electric Light by Incandescence," by John W. Howell, and on "The Steadiness of the Electric Current," by C. W. Siemens.

PUBLICATIONS RECEIVED.

The Wings of Pterodactyls. By Professor O. C. Marsh. Pp. 16. With Plates.

Nature the One and Only Deity; and Humanity in its Entirety, in all its Stages of Being, Nature's Highest Expression. By John Franklin Clark. Boston: Colby & Rich. Pp. 16.

Contributions to the Chemical Laboratory of Harvard College. By Henry B. Hill. Pp. 32.

The Daggatouns, a Tribe of Jewish Origin in the Desert of Sahara: A Review. By Henry Samuel Morais. Philadelphia: Edward Stern & Co. Pp. 14.

Consumption: Is it a Contagious Disease? What can be done to prevent its Ravages? By Bela Cogshall, M. D. Flint, Michigan. Pp. 12.

The Importance of introducing the Study of Hygiene into the Public and other Schools. By Stanford E. Chaillé, M. D., Professor of Physiology, etc., University of Louisiana. New Orleans. Pp. 20.

Annual Report of the Board of Health of the State of Louisiana to the General Assembly, for the Year 1881. New Orleans. Pp. 427.

Little-Known Facts about Well-Known Animals: A Lecture. By Professor C. V. Riley. Washington: Judd & Detweiler. Pp. 32. 10 cents.

State Education. By Charles S. Bryant, A. M. Pp. 16.

On Some Hegelisms. By William James. Cambridge, Massachusetts. Pp. 24.

Notes of Work by Students of Practical Chemistry in the Laboratory of the University of Virginia. No. X. Communicated by J. W. Mallet. London. Pp. 15.

Transactions of the Seismological Society of Japan. Vol. II. July to December, 1880. Tokio: "Japan Mail" Office. Pp. 103. With Charts.

Journal of the American Chemical Society. Vol. III. New York: Lehmaier & Bro., printers, 95 & 97 Fulton Street. Pp. 110.

A Study of the Various Sources of Sugar. By Lewis S. Ware, Member of the American Chemical Society, etc. Philadelphia: Henry Carey Baird & Co. Pp. 66. 50 cents.

Bacilus Anthracis. By George M. Sternberg, Surgeon, United States Army. New York: Thompson & Moreau, 51 & 53 Maiden Lane. Pp. 4. With Plate.

Experiments with Disinfectants. By George M. Sternberg, Surgeon, United States Army. Pp. 12.

A Contribution to the Study of the Bacterial Organisms commonly found upon Exposed Mucous Surfaces, and in the Alimentary Canal of Healthy Individuals. By George M. Sternberg, Surgeon, United States Army. Pp. 24. With Three Photo micrographic Plates.

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POPULAR MISCELLANY.

Sewerage of Large Villages.—Mr. James T. Gardiner, Director of the New York State Survey, has made a valuable report to the New York State Board of Health on the methods of sewerage for cities and large villages. He finds, after inquiry, that where, in general, intelligent efforts have been made to produce proper sanitary conditions for towns, cess-pools and vaults have been abolished, and the sewage is removed from the neighborhood of dwelling-houses by dry removal, or by water-carriage or sewerage. The efficiency of the system of removal by means of the dry earth-closet depends upon constant proper attention. In practice, it is found that the provision of fine, dry earth, and the constant intelligent surveillance necessary, can not be secured from any but

exceptional families. The system can not, therefore, be safely recommended for towns in which a large proportion of the people are always ignorant and careless. The tub, cask, or pail system, which is used even on a large scale in England, France, and Germany, "is undoubtedly the best method of removal, where towns have neither water-supply nor sewerage." In this system, the refuse matter is allowed to fall into a tub or cask, which is removed, emptied, cleaned, and disinfected by the town authorities at least once a week. At Manchester, England, sifted ashes are added during use to the contents of the tub, as a deodorizer. This system is successfully employed at Manchester and Rochdale, England, at an expense of $95 per thousand persons, or ten cents per person per annum; and is recommended for villages which can have no general water-supply. The weakness of it is, that the removal, cleansing, and disinfecting of the tubs require constant care and expense, and may be neglected by careless, ignorant, or parsimonious village authorities—a weakness rather attributable to village authorities than to the system—but under no circumstances could the evils of such neglect be comparable with those of privy-vaults. The system is, however, unavoidably inferior to that of sewerage, in that it does not provide for the removal of waste-water and slops. Mr. Gardiner expresses a decided preference for the "separate" system of sewerage, which is adapted to carry off slops alone, to the "combined" system, in which the attempt is made to carry off both slops and storm-water by means of one set of conduits. He regards the separate system as vastly cheaper than the combined, and as very much more wholesome, in that it does not supply the territory for the cultivation of the bacteria that find rich and extensive propagating grounds on the moist, unglazed walls of the large combined sewers. A conspicuous example of the successful application of the separate system is found at Memphis, Tennessee.

Origin of the Sun's Light and Heat.—Dr. H. R. Rogers, of Dunkirk, New York, has come forward with a criticism of the existing theories of the origin of the light and heat of the sun from combustion, mechanical action, or shrinkage of the sun's mass, as insufficient and not adequately supported by the analogies of any facts with which we are acquainted, and has advanced a theory that they are the result of electrical action. The sun, he believes, is a cold body, like the earth, but so constituted and so situated relatively to the earth that a stream of electric currents is constantly passing between the sun and the earth. These currents reach their points of greatest intensity within our atmosphere, where all the manifestations of force which we assign to the sun's surface really take place. Dr. Rogers also believes that the phenomena of gravitation may be traced to the same origin.

The Germination and Vitality of Seeds.—Dr. Richard E. Kunze, has collected a number of facts respecting the germination and vitality of seeds, in an essay which was read by him before the Torrey Botanical Club last December. Some seeds, to grow, must be planted immediately on maturity. Familiar examples are those of the elm and maple, the oak, and most of our common nuts. The seeds of the larkspur (*Delphinium formosum*), of some gentians, and of *Angelica*, partake of this character. Spanish chestnuts and filberts, however, have been sent, enveloped in wax, to the Himalayas, and plants from them are now growing there. Seeds of the *Victoria regia* had to be transmitted from America to England in water before the first plant was raised that came to perfection. Bosse, a German horticulturist, says that, when seed is to be kept for any length of time, it should be left in its natural covering. Other means of protection are sometimes available to preserve perishable seeds. Acorns will keep, packed in the hard ground, for centuries, and many seeds may be safely kept or transported in honey. Some seeds, like those of the *Cucurbitaceæ*, the balsam, stock, and wall-flower, improve with age to a certain extent. Many seeds are capable of preserving their vitality for years under ordinary conditions of dry exposure. Experiments by M. Alphonse de Candolle indicated that woody species preserved the power of germinating longer than others, while biennials were at the opposite end of the scale,

and perennial herbs lost their vitality sooner than annual ones. Of three hundred and sixty-eight species of seeds fifteen years old, that he sowed, only seventeen germinated, and but few of the species came up. The seed of radish has grown freely at fifteen years; that of *Sida Abutilon* at twenty-five; those of melon and tobacco at forty; that of the sensitive-plant at sixty. A committee of the British Association reported in 1847, after seventeen years of examination, that the *Leguminosœ*, considered as a family, appeared to possess more vitality than any other; next came the *Malvaceœ*, *Tiliaceœ*, and Croton, of the *Euphorbiaceœ*, among those kinds whose seeds grow after ten or more years. Apparently well-authenticated instances of seeds that have grown after having been preserved from a remote antiquity are not rare. Plants have been raised from seeds found along with coins of the Emperor Hadrian, in an ancient barrow in England—*Medicago* and a heliotrope from a Roman tomb, fifteen or sixteen hundred years old, where they had been put in a bag under the head of the corpse for a pillow. The genuineness of some of the specimens of so-called "Egyptian wheat" has sometimes been questioned, but Mr. M. F. Tupper obtained plants from grains which Sir Gardiner Wilkinson took from a previously unopened mummy-case, and gave to Mr. Pettigrew, who gave them to him. Rose-seeds and doura-seeds, the genuineness of whose ancient Egyptian origin is equally well authenticated, have grown, the former with Mrs. Governor Wood, at Quincy, Illinois, the latter with the Rev. Albert Hale, of Springfield, Illinois. Professor John Henry Carroll, of the College of Archæology and Æsthetics of the City of New York, has raised Indian corn from seed taken from a Peruvian mummy supposed to be twelve hundred years old.

A Criticism of Medical Schools.—Dr. Frederic R. Sturgis, in a paper read before the Medical Society of the State of New York, strongly denounces the present systems and standards of medical education. Noticing some unfavorable criticisms that have appeared of the general culture and manners of young physicians, he attributes the origin of the condition which the criticisms expose to the unregulated management of the medical schools. They are nearly all private business enterprises, and have to look to their fees for their support. Hence, while they are always on the alert for whatever may tend to increase their fees, they are easily enough prone to neglect or overlook what may have no direct bearing upon that point, though it may be of the utmost importance in relation to the fitness of the student to become an acceptable practitioner, and a desirable acquisition to the community in which he may settle himself. The charters of medical schools are too easily obtained, and not sufficiently guarded, to make it sure that the school will be a useful agency, or even that it will not do harm. "There is nothing," says Dr. Sturgis, "making the educational candidate for a charter show just cause for its existence, nor anything binding it to give good and proper instruction; hence, as soon as its charter is obtained, it may do as it pleases—teach or not, as it likes; or, if it prefers it, may sell its diplomas." The remedy for this evil is the pecuniary endowment of schools, by means of which they may be able to limit themselves to their proper office of serving as places of instruction and nothing else, and be relieved of the necessity of making their diplomas licenses to practice, "which right ought never to have been given them." Then branches can be taught, such as public hygiene, medical jurisprudence, and the like, which have now to be passed over in silence, or else very superficially taught; and the institution which gives the best instruction will, other things being equal, receive the most students. In a word, the concern of the institution should be, in the language of President Eliot, "to have a very good school of medicine, rather than a very large one."

Provincial Accents among Deaf-Mutes.—A topic has been under discussion in the French Academy of Sciences that involves the question whether provincial accents in speech are or are not the result of local peculiarities in the structure of the vocal organs. M. F. Hément has observed that the deaf and dumb children in a certain institution, who had been taught to articulate

sounds, speak with the accent of their country; and he believes that, as they have never heard any one speak, their peculiar accent can only proceed from their having organic conformations like those of their parents. M. Hément is supported by a communication from Mr. W. E. A. Axon, published in "Nature." M. Emil Blanchard, contradicting this view, cited the example of a French-speaking Chinaman with whom he had talked, who had no trouble with his *r*'s; and he suggested that the question could not be considered satisfactorily solved till a number of children of people speaking peculiar idioms had been separated from their parents from birth, and taught to speak a single language. Mr. A. Graham Bell has communicated a paper to the "Academy," stating that, in observing the pronunciation of at least four hundred deaf-mutes whom he had taught to speak, he has never remarked any tendency of the kind described by M. Hément. In some cases, it was true, dialectic accents could be detected; but he has always found, on investigation, that such children had been able to speak before they became deaf. M. Hément declares that his opinions are not shaken by Mr. Bell's observations, and even professes to find in them new arguments in support of his own theory.

Insect Enemies of Forest and Shade Trees.—Dr. A. S. Packard, Jr., of the United States Entomological Commission, has published a valuable report on insects injurious to forest and shade trees, which is intended, not so much to embody the fruits of any original research, as to give a summary of what is up to this time known of the habits and appearance of such insects as are injurious to the more useful kinds of trees. The amount of knowledge we have on the subject is really scanty enough, and the report is, therefore, largely a simple list of the insects that live upon our more important forest-trees. The matter is eminently worthy of the attention of farmers and gardeners and others, who have the opportunity and are competent to make intelligent investigations relative to it and inform naturalists of what they find out; and such persons are invited to communicate the substance of their observations to the commission. Much has been done in France and Germany, both of which countries possess valuable illustrated works on forest-insects. Kaltenbach, in his work on the insect enemies of plants, describes astonishing numbers of insects as found on some kinds of forest-trees, only a comparative few of which are, however, particularly destructive. Thus, 537 species are injurious to the oak, and 107 are obnoxious to the elm; the poplars afford a livelihood to 264 kinds; the willows yield food to 396 species, the birches harbor 270, the alder 119, the beech 154, the hazel-nut 97, and the hornbeam 88. Among the coniferous trees, the junipers supply 33 species, and 299 species prey upon the pines, larches, spruces, and firs collectively. In France, Perris has observed more than one hundred species either injurious to the maritime pine or living upon it without being especially injurious to it. The number known to attack the different kinds of trees in the United States is sufficiently large to excite great fears for the future prosperity of our diminished forests unless some means are found to check their increase, and the subject of forest entomology is becoming one of really great importance.

Domestication of Wild Ducks.—Mr. Charles Linden has made report to the Buffalo Society of Natural Sciences of the experiments which Mr. George Irwin, of Mayville, on Chautauqua Lake, has been conducting for more than thirty years in the domestication of several species of wild duck. A suitable lot of about an acre in extent, on the edge of the lake, was fitted up with protecting sheds and nesting-places, and stocked from time to time with eggs for hatching, ducklings, and old birds. The pin-tail and American swan freely bred and raised their young in the inclosure, without any more restraint than was necessary for safe-keeping, but were never fully domesticated, nor even transferred from the breeding-pen to the barn-yard. The dusky duck and mallard, which proved most tractable for domestication or complete metamorphosis into tamed barn-yard fowl, resisted all efforts for this purpose if they were transferred to the pen when one year old, but were readily tamed when they were raised from eggs or capt-

ured young. "The majority of them seemed to feel as much at home here as in any nesting-ground of their own choice, and generally returned whenever they were permitted to migrate in autumn." The progeny of the Canada goose as well as of the other species prospered well and became large. Some of the progeny are still living, and betray in many instances a tendency to revert, as to plumage, but the majority have become completely metamorphosed into barn-yard fowl. No hybrids from different species were obtained, except from crosses between the mallard and the dusky duck. The food of all the ducks was what they ate in the wild state—grains, acorns, etc.; and shoots and roots of aquatic plants for the wood-ducks. All the species experimented with migrated southward, if not maimed, each autumn, and invariably returned with a male mate, which remained till the female began to hatch, when it went away, never to return. The crosses obtained with tame birds retained their original plumage to a greater or less degree, but were of increased size. It appears from the experiments that the majority of our wild ducks are not easily prone to change their wild condition for that of perfect domestication, but that they manifest no aversion to breed freely, even when they are placed under artificial restraints.

Siberian Products.—The following facts indicate that Siberia may be destined to occupy a place of considerable importance in the world's trade: Gold, silver, platinum, lead, copper, and iron are found in the Ural. The gold product of that region (nearly all of it being drift-gold) amounted in 1876 to between 140 and 150 centners; and the whole product of Siberia in 1877 was estimated at about 780 centners. Coal-beds exist in the Ural, in the Kirghiz steppes, on the northern borders of the Altai Mountains, on Lake Baikal, and on the Amoor River. Graphite-beds have long been worked in the Shian Mountains, and other graphite beds are waiting exploitation on the lower Tunguska. Agriculture and cattle-raising do not flourish, notwithstanding some favoring circumstances, on account of the deficiency of outlets and labor. The fur-trade is not so important as it formerly was; for the silver-fox, ermine, and sable have become scarce. The fisheries afford an important article of export, but they are carried on in the most primitive manner. The opening of the Arctic Ocean to navigation and the extension of the railroad that now reaches to Ekaterinburg will be of great advantage to the future of Siberia.

Miracles not out of Date.—Dr. Giordano has reported upon a remarkable epidemic of morbid fanaticism which is prevailing in the village of Alia, in Italy. The place is almost inaccessible, having but little intercourse with the world, and is marked by a barbarous style of living, and by the prevalence of intermarriage, with its usual concomitants of weak-mindedness, morbidness, and idiocy; consequently, superstition flourishes. After a long drought in February, March, and April last, a religious procession was organized to obtain rain. The statue of Saint Francis was carried round, and the declaration of a fanatic that he saw water flowing on the face of the saint was readily taken up by the credulous crowd. The miracle was attributed to the intercession of a girl named Rosalia Giallonbarda, who, having formerly suffered from epilepsy, believed she had been cured by the saint, and was the subject of an excessive mysticism, with hallucinations. Her frenzy was caught by her relatives and neighbors, and spread abroad till the crowds of fanatics coming to visit her and the saint became so formidable that she was arrested. This "sacrilege" only stimulated the popular excitement.

Silk-spinning Spiders.—The spiders, large *Epeiridæ*, which produce silk, inhabit the hottest countries. They are represented in our latitudes by a few species of inferior size, the most common of which, the *Epeira diadema*, is very numerous in gardens in the fall, and may be remarked by the regularly shaped webs which it weaves among the bushes. These delicate gauzes, however, give only an imperfect idea of the webs that are woven by the larger species of tropical regions. In India, the Sunda Islands, Madagascar, Réunion, and Mauritius, the *Epeiræ* construct webs of extraordinary dimensions, and the traveler has fre-

quent cause to admire the threads which he finds strung across the water-courses, and fastened to the trees on the opposite sides. The threads of these spiders are of different kinds, and proceed from different glands. The silk which is wrapped around the cocoons is not the same that is spun in the webs, and may be of an entirely different color. The silks of various *Epeiræ* were brought to Europe by travelers in the seventeenth century, and excited admiration by their fineness and brilliancy. Experiments were tried in making cloth and gloves from them, but they were found to have no powers of endurance. Louis XIV, wishing to encourage a new art, had a coat made of the silk, but was glad to take it off the first day, for it suffered a rent every time he moved. These efforts appear to have been made with the silk of the webs. That unrolled from the cocoons proved to be stronger. M. Bon, in 1709, carded from the cocoons a silk which he described as much finer and stronger than ordinary silk, and which, he claimed, was fitted to make any kind of fabrics. In Spain, Raymondo María de Tremezer, between 1777 and 1791, made several articles as bright and fine as silk from the threads of the *Epeira diadema*. Mr. Rolt, an English merchant, was able to exhibit to the Society of Arts a specimen thread twenty thousand feet long, that had been spun by twenty-two spiders in less than two hours, and which was five times as fine as the thread of the silk-worm! Alcide d'Orbigny asserted that he had garments, able to sustain considerable wear, made in South America from spiders' silk.

Food and Civilization.—M. Beketoff, a Russian hygienist, has expressed some novel views in a paper on "The Alimentation of the Human Race in the Present and the Future." Physiologists are accustomed to consider a mixed diet, of which meat shall constitute about one third, to be the best for mankind in general, and to be almost essential to the best development. M. Beketoff does not consider this view to be well founded, or sustained by the facts as they appear on examination of the diet of the best races. A large majority of mankind do not use meat, nor a mixture of meat and vegetables, but vegetables alone, as food. The people of Europe consume more meat than those of any other part of the Old World, but most of it is used in the cities, while the country people enjoy only a small fraction of the quantity which the physiologists say they need, and it has come to that point that, in the most civilized part of the world, meat is only not wholly left out of the list of common foods. In the most populous and most civilized parts of Asia, as in China and India, cattle-raising is quite insignificant, and in Japan can hardly be said to exist at all. The Africans raise cattle, but live chiefly on vegetables. Only in North and South America and Australia is meat consumed on a really large scale. Not only the relative, but the absolute number of cattle also, shows a tendency to diminish as the population increases and the ground is more devoted to tillage; so that the prospect is apparent that, with the continuous development of agriculture, industries, civilization, and population, cattle-raising will pass into real insignificance, and the mass of men will be unable to obtain animal food. Sources of vegetable food must be found, to supply its place, among the plants richest in albuminous substances. The legumes are the most prominent of these plants. To determine the power of beans to sustain all the functions of life, Dr. Virochiloff performed a series of experiments upon himself, by eating regularly equal quantities of bread and sugar, and adding to them for a certain time meats, for another period peas. The result was, in his own words, that "both the mixtures quite fulfilled the purpose of nutrition, as was proved by the same weight of body being kept up and the forces being maintained in the same state by either food." The meat-mixture was, however, assimilated more readily than that of which the peas formed a part. It is affirmed that men occupied in intellectual work especially need a mixed food; but of this we are not certain, not knowing on what those whose intellectual achievements have been greatest have really lived; and many of them have been very irregular eaters. Taking the history of the human race as a whole, we may observe that races living almost exclusively on meat have been and are the most savage ones. The prehistoric "finds" show that the beginnings

of civilization and of the cultivation of plants kept pace with each other. This does not prove that a meat diet is opposed to civilization, but that the necessities of people who are dependent on meat for food hinder advance in civilization. They have to be hunting, and wandering about from place to place. It is when they have learned to till fields and tame animals, and have become fixed in homes, that they find time to cultivate arts. The Arctic savages are fish-hunters, the barbarians of the Asiatic steppes depend on their herds, the meat-eating Turks and Mongols were more barbarous than the vegetable-eating Hindoos they conquered, and were the authors of the woes of that suffering people. M. Beketoff's conclusion is that a vegetable diet contributes more than any other to the intellectual development of a people, while a wholly animal diet determines a kind of life incompatible with progress. A mixed diet has not been the promoter of civilization, for the most highly gifted authors have often drawn their physical forces from a wholly vegetable diet. Finally, "the great thing is evidently not the kind of food, but the kind of life that the food determines."

Synthesis of Indigo.—One of the most important of the recent discoveries in chemistry is that which Baeyer has made of a practical process for the artificial production of indigo. The successful experiments of this chemist had been foreshadowed by the production of alizarene, the coloring principle of the madder-root, from the anthracene of coal-tar; by the discoveries by Fritsche of the relations of indigo with the benzene ring and the amido-group; by Erdmann and Laurent's discovery that indigo on oxidation yields a crystalline body possessing no coloring power, to which they gave the name of *isatin;* and by Baeyer and Emmerling's accomplishment of the reverse process of reducing isatin to indigo. Three processes have been employed for the synthesis of indigo, of which, however, only one, by Baeyer, is of practical importance. The three processes have in common that they all proceed from some compound containing the benzene nucleus; that they all start from compounds containing a nitrogen-atom; and that they all commence with an ortho-compound. They differ from each other in that Baeyer's process requires the abstraction of an atom of carbon, while of the others one requires the addition of an atom of carbon, and the second starts with the right number of atoms of carbon. Baeyer's successful process, which may be called the manufacturing process, starts from cinnamic acid, a substance which is contained in gum-benzoin, balsam of Peru, and a few other aromatic bodies, but which can be obtained more cheaply by manufacturing it artificially. Bertagnini has obtained it from oil of bitter almonds; and other processes for the same purpose have been carried out. One of the processes most likely to be adopted is that of Dr. Caro, who converts toluene, by adding chlorine, into benzylene dichloride, and treating the latter substance with sodium acetate, forms cinnamic acid and sodium chloride. The next steps in the process are the formation from cinnamic acid of ortho-nitro-cinnamic acid; the conversion of this into its di-bromide; the separation from this of the two molecules of hydrobromic acid, which gives rise to ortho-nitro-phenyl-propriolic acid; and, lastly, the conversion of the latter product into indigo by heating its alkaline solution with grape-sugar, xanthate of soda, or some other reducing agent. The actual yield of indigo by the last reaction has not been made equal to what is demanded by theory, it being only 48 per cent, while the theoretical yield would be 68 per cent. The artificial production of indigo by this process may be considered as within reasonable distance of commercial success, for the ortho-nitro-phenyl-propriolic acid, the colorless substance which, on treatment with a reducing agent, yields indigo-blue, is already in the hands of the Manchester calico-printers, and may be obtained at the price of six shillings per pound of a paste containing 25 per cent of the dry acid. Indigo can not, however, be made profitably from this product till the theoretical yield can be obtained from it, and until the price of the dry propriolic acid can be reduced to 20*s.* per kilo, or 8*s.* ($2.00) a pound. The process may, however, be found applicable with advantage even at present rates, for uses for which natural indigo is unfitted. Of the other processes for manufacturing indigo,

the first starts from ortho-nitro-benzoic acid, which yields isatin after successive treatment with phosphorus pentachloride, silver cyanide, caustic potash, and nascent hydrogen. The other, also by Baeyer, starts from ortho-nitro-phenyl-acetic acid, which, having been obtained synthetically from toluol, is converted into the amido-acid, then by the loss of water into a body called oxindol, from which isatin, and therefore indigo, can be obtained.

Tobaccoism.—M. Thorens has published some observations on *angina pectoris* caused by tobaccoism. His attention was called to the subject by the case of a patient who had most of the symptoms of angina pectoris, but in whom no cause for the affection could be found except excessive smoking. The patient smoked cigarettes, and swallowed the smoke, thus making the whole quantity of smoke pass through the lungs. Evidently the opportunities given for the absorption of smoke and nicotine in this case were colossal in comparison with those which would exist in a person smoking ten times as much, but in an open place and without swallowing the smoke. Another circumstance aggravating the affection was, that the patient smoked his cigarettes directly, without the intervention of a holder, so that the smoke reached his mouth hot, without any chance having been given for the condensation of any of the volatile products. His mouth was, moreover, in constant contact with the tobacco-leaves, so that the liability of absorption by the buccal membrane was greatly increased. Similar affections arising from similar causes had been noticed by Beau and M. Gélineau, a naval surgeon, both of whom observed that the trouble was mitigated when the use of tobacco was moderated. The case suggests a number of precautions to be observed by persons who will smoke but desire to do themselves as little harm as possible, among which are never to swallow or inhale the smoke; to avoid smoking in an inclosed place, or at least to have the room as large and as well ventilated as possible; and to put as considerable a distance as is practicable between the light and the mouth, always using for this purpose long-stemmed pipes or cigar-holders. The driest tobacco and that which is weakest in nicotine, should be preferred. M. Thorens exonerates tobacco from the charge of producing cancer, although it is of course liable to irritate a wound already made, or a surface that has already been injured by heat.

The Horse in America.—It has been generally believed that the horse was introduced into America by the Spaniards. Professor Marsh, on the other hand, has found abundant remains of probable ancestors of the horse in our Western geological formations; so that, if there were no horses before the Spaniards came, there must have occurred a failure of the race. Mr. E. L. Berthoud, of Golden, Colorado, believes that he has evidence that the Spaniards found horses in South America when they first visited it. Among the maps which he has recently received from Paris, in a collection of the fifteenth and sixteenth centuries, is one which Sebastian Cabot drew for the Emperor Charles V, representing his explorations of the La Plata and Paraná Rivers, and containing symbols of the animals and plants that he found. Among these symbols was that of the horse represented near the plains of the Gran Chaco, where the immense herds of that animal range to-day. He claims that this affords a fair presumption of the native origin of the race, for neither the Spaniards nor the Portuguese had then been long enough in the country (in 1527) for their horses to have escaped from Peru to the head of the Paraguay and Paraná Rivers and to have increased in numbers sufficiently to attract attention.

The Protective Organs of Plants.—Dr. A. Tschirch has recently published some interesting observations on the relations of the anatomical structure of plants to climate and location. In the first place, the adjustment of the breathing-pores appears to be adaptable to a variety of external conditions in different plants of the same family. In plants that grow in a moist atmosphere, the pores are exposed with but slight protection; while the means of protection appear to increase gradually as the habitat becomes drier, and reach the highest point in desert plants. The closed cells

that lie partly outside of the epidermis enjoy the least protection, as in certain ferns, while a higher degree of protection is given when the cells are sunk beneath the epidermis and framed in a kind of funnel; and the highest degree when the stomata are arranged in rings or ovals on the under-side of a rolled leaf. Another means of protection is afforded by the structure of the epidermis, which is fortified by a strong cuticular structure, hardly permeable to vapor in many Australian plants, and is sometimes re-enforced by deposits of oxalate of lime. Such structures are peculiar to plants which have to sustain great drought. The epidermis of many plants, as the *Eucalyptus globulus*, is also covered with a coating of wax, which serves not only to protect it, but also to give a deeper setting to the pores. The protective effect of hairs operates in several ways: they cover the pores; they form a kind of space over the pores in which air and vapor may collect; and they constitute a kind of screen over the whole body of epidermis-cells against insolation and desiccation. Thus, plants growing on high, dry mountains, or in the steppes, are generally thickly haired. Hairs also serve to make the plant measurably defiant of sudden changes of temperature, and form an important part of the vegetable economy of regions like Soodan and continental Australia, which are subject to such changes. Even in temperate climates, varieties of the same species growing in open and exposed places are more hairy than those growing in protected woods. In the eucalyptuses the intercellular spaces and air-passages of plants growing in dry situations are much contracted, while in those growing in valleys and along rivers they are expanded. Willkomm has called attention to the fact that a sap strong in saline solutions is much less subject to evaporation than a thinner sap; and thus the *halophytes* keep fresh in stony places and the driest climates, while the *Chenopodiaceæ* (goose-foots), with much salt in their juices, flourish in dry places, and are met abundantly in the Asiatic steppes and the interior of Australia; and these look green and vigorous in the driest time of the year, when everything else is parched and brown. The form and position of the leaf also often show an adaptation to help the plant resist drought. Plants having to grow in a dry climate generally exchange the usual broad leaves for a narrow, close one, have it reduced to a cylindrical form, or, as in the brooms, make a green limb serve them as the assimilating organ. Broad leaves are seldom found in very dry regions. Many species peculiar to hot and dry situations have a faculty of arranging their leaves vertically, so that only the edge is exposed. The *Lactuca scariola*, the only European plant having this peculiarity, grows on roadsides and dry hills, while all the other species of lettuce, growing in shady and moist places, and in gardens, have the leaves arranged in the ordinary way, except that *Lactuca sativa* puts out vertical leaves when it is growing in a thin soil. The ethereal oils and thorns of plants may also possibly serve some protective purpose, but this is a subject for further investigation.

Terra del Fuegians in Paris.—Eleven natives of Terra del Fuego, four men, four women, and three children, were taken to Europe by M. Waalen, who has resided for several years at Punta Arenas, Patagonia, and have been entertained at the Jardin d'Acclimatation in Paris. M. Waalen was fishing for seals in the waters of their inhospitable island when he came in contact with these savages, and succeeded, by giving them plenty to eat and treating them with tact, in getting them to stay on his vessel, whence they were transferred to a Hamburg steamer on its way to Europe, M. Waalen depositing security with the governor of Punta Arenas for their safe return after making their European tour. What mark their visit will make upon them, and how long it will endure, is a question which the experiment of Captain Fitzroy may help to answer. He took back three Fuegians, two men and a woman, after they had been three years in Europe, and had seemed to become nearly civilized, and set them among their tribe, in a good house, with a tract of tillable land, tools, and a missionary to take care of them. Going back to see them a few months afterward, he found all that pertained to civilization destroyed, that they had returned to complete savagery, and that the missionary was

anxious to get away from them. The Fuegians in Paris are described as accustomed to squat for hours, without moving, around a fire on the lawn, perfectly indifferent to everything, and listlessly looking at the crowd who peer at them through the bars of the fence as if they were some extraordinary animals, and as occasionally exchanging with each other the guttural cluckings which serve them for a language. Only one thing will excite liveliness in them—the desire for food.

Forms of Aurora Borealis.—Lieutenant Weyprecht, in his recent work on the observation of the aurora borealis, distinguishes between seven forms in which the light appears in the polar regions. The first form is that of almost regular arches rising or sinking from the magnetic south or north to or away from the zenith, and generally extending to both sides of the horizon. Second, are streamers of irregular form and varied appearance, appearing like bands much longer than broad, moving in the atmosphere, and nearly always bent in folds and twists; they consist either of masses of light unequally distributed along the length of the band, or of single beams of the breadth of the band closely arranged together in a direction toward the magnetic zenith, and having their intervals filled with light-masses. This form is cut away on every side, or at most touches the horizon on only one side. Of the third form are threads, extremely fine beams of light of various lengths, some of them reaching from near the magnetic zenith to near the horizon, and grouped in such a manner as to resemble a fan covering a part of the firmament. The beams are not united, but are separated by dark spaces of greater or less width. Generally, they are prolongations of a streamer, which in such case answers to the continuous lower border of the fan. Fourth, is the corona, in which the beams or light-masses are joined in a common center near the magnetic zenith, and a constant movement is maintained toward or around the same. Fifth, haze—dim, unformed accumulations of light-masses illy defined, at some point in the firmament. Sixth, the dark segment, a darker appearance, forming a segment of a circle, in the magnetic north or south, bounded by a fixed and low-seated bow of light. Seventh, the polar shine, an illumination of the polar sky, the form in which the light generally appears in middle latitudes, but which is not observed in its home. Its characteristic feature is that the rays diverge from the horizon up, while the divergence in all the other forms, if their rays can be distinguished, is in the reverse direction. The movements of the mass consist either of a rising and sinking of the rays and arches with reference to the horizon, a lengthening, and shortening, and sidewise motion of the threads, or a general change of place. The mass has also motions within itself, which may consist of undulations or flashes of the light. The undulations are waves, streamers, or partial arches, which pass along generally from the magnetic east or west, toward the opposite end of the phenomenon, and then appear to spring out from it. The flashes are the shooting of short, broad beams, with the velocity of lightning, from the streamers toward or from the zenith. They are the forerunners or accompaniments of intensive coronas, and originate in particular when a stream of rays merges into the corona.

Wyville Thomson.—The death of Sir Charles Wyville Thomson, in the fifty-fourth year of his age, is announced. He was born in Linlithgow, Scotland; began his medical training at Edinburgh University in 1845; held a Lectureship on Botany at King's College, Aberdeen, in 1850; and has occupied professorial chairs in science at King's College, Cork, Belfast, and Edinburgh, where he succeeded Professor Allman as Professor of Natural History in 1870. He has contributed many papers of merit to scientific societies and periodicals, beginning with one on the application of photography to the compound microscope, which was read before the British Association in 1850. His most distinguished service, and one by which he won an enduring fame, was as Director of the Civilian Scientific Staff of the Challenger Expedition, where he gave unremitting personal attention to the dredging operations, and the examination of specimens. He had been for some time in feeble health, and his death followed his becoming severely chilled on a visit to Edinburgh. "Sir Wy-

ville was an excellent lecturer, a most genial companion, and an excellent host," and was fond of amusements of all kinds.

NOTES.

THE Boston Society of Natural History announces that a sea-side laboratory, under the direction of its curator, will be opened at Annisquam, Massachusetts, July 1, to continue until September 1, 1882. A limited number of students can be accommodated, and the work will consist mainly of study and observation of the common types of marine animals, under the immediate care of Mr. B. H. Van Vleck, assistant in the museum and laboratory of the society. Full particulars may be obtained by addressing the curator of the society, Professor Alpheus Hyatt, of Boston.

THE French Association for the Advancement of Science will meet at La Rochelle, August 24th to 31st. The organization of the congress is already in active preparation. M. Jousset de Bellesme has published a note calling attention, as the topics most likely to attract the interest of zoölogists, to ostreiculture, which is carried on along the neighboring coasts; to termites, whose nests are found in the vicinity; and to several valuable collections of the local fauna. Among the excursions will be dredging expeditions at sea, and geological excursions under the guidance of local experts.

THE account of the late Professor Clerk Maxwell, to be published by Messrs. Macmillan & Co., will include a biographical outline, with selections from correspondence, by Professor Lewis Campbell, who was very intimate with Mr. Maxwell in early life; an account of his chief contributions to science, by Mr. William Garnett, who was associated with him as demonstrator at the Cavendish Laboratory for the last six years of his life; and a collection of his poems, some of which are already known to the public, while the greater number will be published for the first time.

JOHN CHARLES FREDERICK ZOELLNER, Professor of Physical Astronomy in the University of Leipsic, died April 29th. He was born in Berlin in 1834. After receiving the degree of Doctor of Philosophy at Basle, he devoted himself to the study of photometry as applied to astronomy and physiology. He was the author of several works on subjects related to astronomy and photometry, the best known of which is that "On the Nature of Comets." He invented the spectroscope which is generally used by astronomers for the observation of the solar protuberances and the lines of their spectrum. He was specially prominent in the later years of his life through his efforts to explain the alleged phenomena of spiritualism by means of a fourth dimension of space.

AN extraordinarily high death-rate which was recorded in London for the week ending February 11, 1882, was ascribed to the dense fogs which had been prevailing. This view is strongly confirmed by the fact that the only weeks in which similarly high death-rates have been recorded during recent years were those ending December 20, 1873, and February 7, 1880, each of which immediately followed a period of dense fog and intense cold. It is also sustained by the fact that the death-rate for the week ending February 11, 1882, in the twenty-seven large provincial towns, was more than ten per cent below that of London; which goes to show that the increase of deaths was caused by the fog rather than by the cold.

THE Popular Observatory, which was opened by M. Jaubert on the Trocadéro, Paris, in July, 1880, has been visited by several thousand persons desiring to observe the stars, more than two thousand of whom have enrolled themselves as regular astronomical or microscopic observers, or attendants on the lectures. The pupils of the Popular School of Astronomy have made a considerable number of observations, of which they have given accounts in a journal, and several of them have associated themselves to put up a laboratory at their own expense. M. Jaubert has established a popular scientific class, meeting twice a week, which is largely attended by teachers.

THE value of porcelain depends on the purity of its color, and this is dependent on the absence of dark spots in the clay, which are produced chiefly by particles of iron. These particles are now extracted at some of the French factories by means of large electro-magnets, which are kept in operation by the steam-power used in other departments of the manufacture. At Mehun three machines purify about 600 kilogrammes (or 1,500 pounds) of porcelain paste every day, the proportion of impurities found averaging about 8 kilogrammes of impurities to 100,000 kilogrammes of paste.

DR. JOSEF CHAVANNE, the Austrian geographer, estimates the mean altitude of the Continent of Africa to be 2,169·93 feet, or double the mean altitude of the Continent of Europe, which M. G. Leipoldt has estimated at 971·41 feet. According to M. Chavanne, if the Atlas range were spread over the entire Continent of Africa, it would give a height of 85·86 feet only, while the Abyssinian mountain-mass would similarly give a height of 79·72 feet.

Dr. Carl Vogt has declared, peremptorily, that "the organisms in meteorites announced by M. Hahn have no existence; what have been described as such result from crystalline conformations which are absolutely inorganic. None of the imagined organisms have the microscopic structure belonging to the organisms with which they have been associated. In particular, the asserted sponges do not show the structure of either existing or fossil sponges; the so-called corals do not show that of polops or anthozoa; and the imagined crinoids do not show the structure of known crinoids. The observed structures are due to an opaque crust, or result from optical illusions, caused by an incomplete method of conducting microscopic researches."

Signor Roncelli, of the Italian Parliament, has devised a simple and practical method of voting by electricity. Each member of the House has in front of him a metal plate bearing his name or number, on which are three buttons, marked respectively, "Ay," "No," and "Abstain." The buttons are connected with a central printing apparatus which prints in three separate columns the ayes, noes, and abstentions, according to the buttons touched by the members; while, with every addition to each column, the sum of the votes in the column is automatically recorded.

M. Delahaye has published in the "Revue Industrielle" some facts concerning extraordinary pressures of wind that have been observed in railway management in India. On the 5th of October, 1864, two trains on the Eastern Bengal Railway, one of eight cars, the other of twelve, were blown over during a violent storm. Four other cars were blown down a side-track, and overturned near the station by colliding with other cars which had also been blown there. On the 21st of September, 1878, a long freight-train on the same railway, while going about eight miles an hour, was blown back nearly a mile, although the engine had a full head of steam and the breaks were put on. Half the train was taken off, when the rest could barely make headway. The Indian railway service affords several other cases of trains that were stopped or greatly hindered by strong winds.

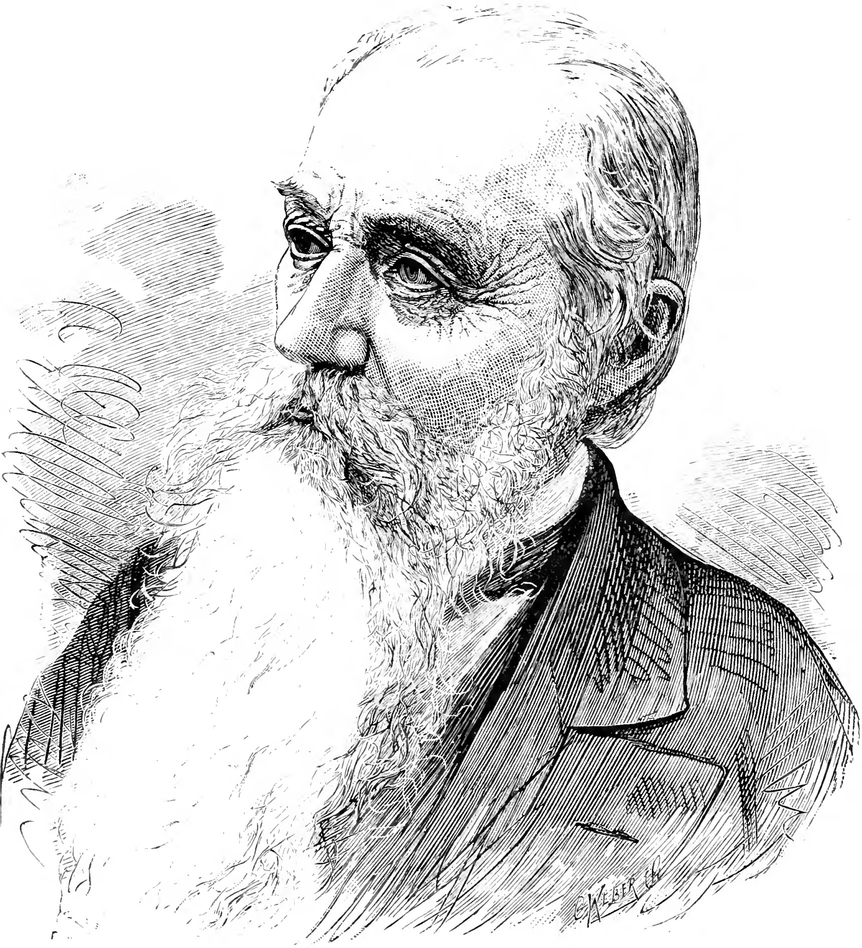
M. Pitre de Lisle has described a singular class of stone celts or hatchets which have been found so far only in Brittany and Northwestern France. They differ from other stone hatchets in having a knob or button-like termination on the butt or hammer end, while other hatchets taper away to a more or less conical point in this part. The blades vary in length from about three inches to about fifteen inches, and are all made of rocks belonging to the family of diorites. M. de Lisle calls these instruments *haches à tête*, or *haches à bouton*—hatchets with heads, or hatchets with buttons. He believes that the object of the expansion was to give greater security to the fastening of the blade or to the holding of it in the hand.

Sir Robert Christison, Professor of Materia Medica in the University of Edinburgh, died January 27th, in the eighty-fifth year of his age. He was the son of a professor in the university, was graduated as Doctor of Medicine in 1819, and became Professor of Medical Jurisprudence in the university in 1822, and of Materia Medica in 1832. His specialty was poisons, on which he published a "Treatise" in 1829 that is still recognized as a work of great value. He received numerous honors on account of his eminence in his department, and held many public positions for which his gifts of knowledge and experience furnished important qualifications. He was elected to the presidency of the British Association in 1876, but declined it on account of his advanced age. He was noted in his youth as the most accomplished athlete in the university.

Besides the contributions in physical science which have, within a year or two, appeared in European journals, from Japanese students, we find that they are doing their share of the work in biological science as well. Within a few months there have appeared in the "Quarterly Journal of Microscopical Science," London, an article on the structure of the gills of *Lamellibranchiates*, by Mr. Mitsukuri; and another paper, by the same author, on the development of the suprarenal bodies in mammalia. In the "Zoologischer Anzeiger," Leipsic, Mr. Ijima gives a condensed summary of a memoir on the structure of the ovary, and the origin of the egg and the egg-string in *Nephelis;* and Mr. Iwakawa gives the results of his observations on the genesis of the egg in *Triton*. The two latter-named gentlemen have never been abroad.

A wealthy land-owner in the Tyrol has made an application of the microphone to the detection of subterranean springs. He fixed the microphones at the spots where he supposed water might exist, each being connected with its telephone and battery. Then, at night, he put his ear to each of the instruments and listened for the murmuring of the waters—and in several cases heard it.

An exposition of electricity is to be held in the Palais Royal at Munich, under the auspices of a committee, of which Dr. G. de Beetz, of the Royal Scientific School, is president.



SAMUEL STEHMAN HALDEMAN.

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PLANT-CELLS AND THEIR CONTENTS.*

By T. H. McBRIDE.

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A CHILD'S toy-balloon may afford us an illustration of what a naturalist might call a typical cell. We have in the toy simply a closed sac thoroughly distended by its contents, more or less perfectly spherical in shape, and affording in outline or cross-section an almost perfect circle. In the organic cell the sac is known as the cell-wall, and whatever may be inclosed by the cell-wall is called the cell-contents. A typical cell would be round, spherical, but very few cells, as they occur in nature, are perfect spheres. A cell which may be spherical at the outset may change its shape in accordance with changing circumstances, so that we may say that the form of all cells which we find united to form tissues varies with the situation which such cells occupy, and the functions of the tissues themselves. This we shall see more clearly as we go on. That vegetable tissues, as they occur in wood, pith, leaves, flowers, and fruit, are entirely composed of cells, may be easily demonstrated. All that is needed is, to take a very thin slice of any of these substances and examine with a microscope of moderate power, when the cellular structure becomes immediately apparent. So, then, all the great variety of form and color, and all the resulting beauty, which the vegetable kingdom affords, and all the varied economic value of plants, depends upon the form and contents of these little organic units—of cells. More than this: these cells are of the highest scientific interest. All the discussion of the past few years in regard to spontaneous generation and the origin of life has been a discussion of vegetable cells; and very much of all that we know about life, its activity and its mystery, has been derived from

* Illustrations from drawings by C. H. Dayton, Mary McBride, and the author.

the study of the cells of growing plants. It becomes, then, a matter of some interest to know something about these cells; and, if the reader can imagine himself for a little while looking through the lenses of our microscope, it will be the purpose of this article to tell him some little of what he may see while he studies the cells of plants.

We may begin with the simplest form of plant-cells; and so, for our first experiment, let us examine a drop of brewer's yeast. Here (Fig. 1) are the cells of the famous yeast-plant, the cells which are the active agents wherever yeast is employed, whether in the beer-vat or batter-crock. In both cases we find the cells producing fermentation: desirable in beer for the sake of the alcohol resulting; in bread, for the carbonic gas set free in form of bubbles, which, permeating the dough, make it spongy and light. But look at the shape of these cells. Little oval bodies they are, some almost round. Many are entirely isolated, so that we see a single cell may constitute the entire plant; some are linked together, as links in a chain. The attachment here, however, is not very intimate, when once the cells have attained their full size, for then each cell readily and naturally parts company with its neighbor—parent, I should rather say, for the cells, as they adhere together, represent really so many successive generations, and illustrate for us one method of cell-multiplication, namely, that which is effected by budding. New cells are continually pushed out as buds on the sides of cells already in existence. The buds grow, reach maturity very rapidly, and in a very short time themselves give rise to new buds and cells. These little yeast-cells, which are not more than three or four ten-thousandths of an inch in diameter at most, are about as simple vegetable cells as we may find anywhere. Growing thus isolated from each other, hardly so much as jostling one another in life's race, there seems no reason why such cells should not be perfectly spherical, or why, so to speak, life's work should not, with them, result in a well-rounded whole.

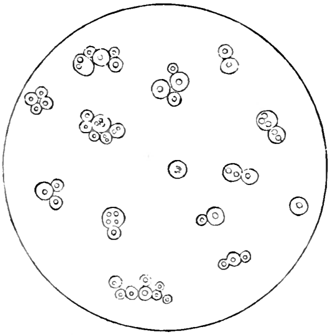


FIG. 1.—YEAST-CELLS.

But the yeast-plant belongs low down in the scale of life, and its simplicity of cell-structure corresponds well with its rank. For the greatest variety of form among plant-cells we must look to higher plants, though not to the highest. The *Algæ*, in their marine forms well known to every gatherer of "sea-moss," and in fresh-water forms familiar to all microscopists, afford cells of almost every imaginable shape, character, and color. Here, as with the yeast-plant, a single cell ofttimes makes up the entire organism, but, while some cells are simple, others branch and divide in all directions: some simulate the

stem, roots, and branches of higher plants, some are tiniest rolling spheres; some stretch away to the length of several feet, and some are microscopic specks. In Fig. 2 we have the representation of a beautiful marine alga, unicellular, and yet thirty inches or more in length.

As we ascend the scale of life we find the individual cell more subordinate to the organism as a whole, and so less complex in itself; and

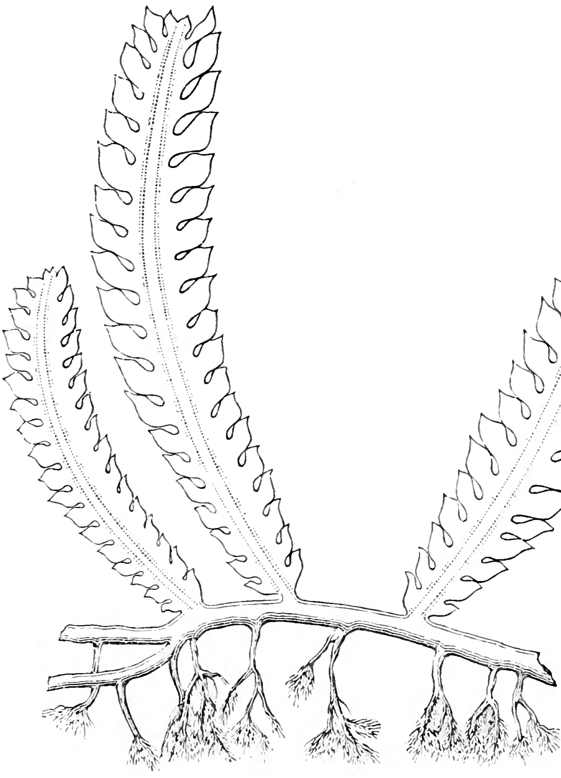


FIG. 2.—UNICELLULAR ALGA (copied from Thomé.)

yet, when we examine the cells which make up the tissues of the best plants we can find, the blooming occupants of our hot-houses, gardens, and fields, we meet with marvelous diversity, and are soon made to feel that variety of form is the law, uniformity the exception. Fig. 3 represents the appearance of a cross-section of a stem of *Tradescantia*. From this section we may learn not the variety of cell-forms only, but something of the manner in which every plant is developed, and something of the porousness of all cellular structure.

But let us tear off with our forceps a little shred of the epidermis of some leaf. The leaf from a petunia will do; that of the wild Jacob's-ladder is better, and that of the wake-robin better still. Let

us examine this little shred with our microscope, using a lens of moderate power. This is from the upper side of the leaf (Fig. 4). How delicate the cell-walls, how beautiful the pattern! Here is Nature's best attempt at uniformity. All these cells serve identically the same purpose, and, so far as we can see, might have been exactly alike. Yet, while there is similarity, no two are just alike. Let us tear off another shred of epidermis, this time from the lower surface of the

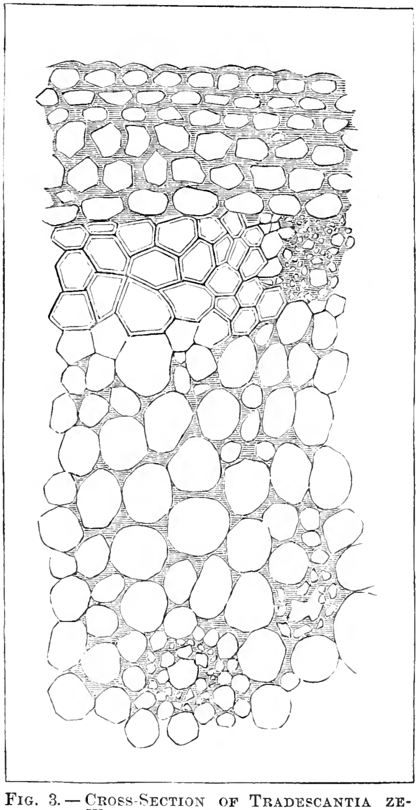


Fig. 3.—Cross-Section of Tradescantia zebrina, Wandering Jew (highly magnified).

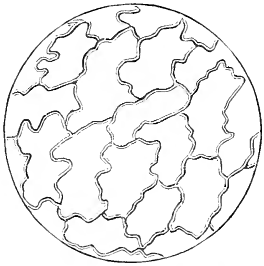


Fig. 4.—Epidermis from the Upper Side of a Leaf.

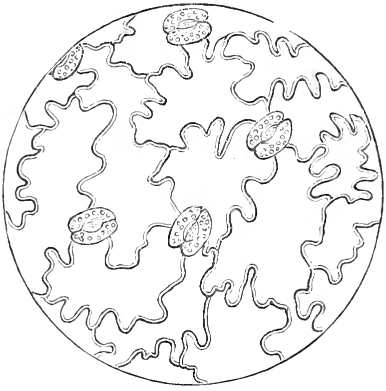


Fig. 5.—Epidermis from the Lower Side of a Leaf.

leaf. Here (Fig. 5) we have the same arrangement and forms of cells, but more beautiful and varied outlines, and the cells are more intimately interlocked. Our magnifying power is greater, and the cells appear larger; moreover, we have before us a few cells altogether unlike any of their neighbors, little button-hole-like structures. These are the stomata of the leaf, and through these tiny *mouths*—for the stomata are real openings through the epidermis—the exchange of gases goes on between the growing plant and the surrounding atmosphere.

Let us now pass on a little further in our investigation of these plant-cells and note the contents of some of them. In our examination

of the cells from the epidermis of the leaf no contents were apparent; in fact, the cells are tabular, very thin in proportion to their width, and any contents they may possess are so nearly homogeneous as to be transparent and invisible. But let us make a thin transverse section of the same leaf. Here (Fig. 6) we find cells different in shape from any we have yet seen, and evidently possessing different contents. The cells from the inside of the leaf are here seen filled with tiny green bodies, sometimes closely packed together, sometimes scattered more sparsely. These little green bodies are the *chlorophyl*-granules, affording to our vegetation all the lovely tints which render charming a landscape in spring. Children of the light are these little green grains, lovers and worshipers of the sun. At all events, they appear by uncounted millions in the bright light of the open sky, become fewer and fewer in proportion as the light received by any plant is diminished, and finally disappear entirely when the plant is left in total darkness. Every one will recall the appearance of potato-stalks where growth has started in some dark corner of the cellar. Cells taken from such growth afford not a sign of chlorophyl. Botanists tell us that the petals of flowers are only altered leaves. In petal-cells, then, instead of chlorophyl-grains, we find in some cases granules of yellow, sometimes of orange. Sometimes the cell contains no such granules, but rather some colored fluid, red, blue, or purple, and then our flowers are tinted accordingly; sometimes the cells of a petal contain air only, and then the flower is white.

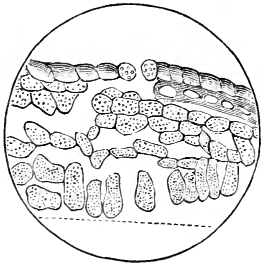


FIG. 6.—CROSS-SECTION OF A LEAF, SHOWING THE CELLS CONTAINING CHLOROPHYL.

But these tiny green grains in the leaf-cells do vastly more than simply lend their color to the foliage; they are readjusters and organizers, and perform, in those diminutive laboratories we have been calling cells, feats which the chemist strives in vain to rival. They take possession of molecules of carbon dioxide and of water, compel the binding chemical forces to relax their hold, combine again, to serve the purposes of the plant, the atoms of carbon, of hydrogen, using such part of the oxygen as may be necessary, and setting the remainder free in the open atmosphere—all this in the sunlight. The chlorophyl bodies thus work while it is day, have charge of nearly all the income of the plant, and provide in themselves for the temporary storage of its daily accumulations, mostly in the form of starch. When the night comes, these same little factors give up at once their labors and their stores, other cells of the plant begin to work, change and transfer and change again, until all the wondrous series of vegetable products with which we are familiar (the sugars, the oils, the alkaloids, crystals of various forms and kinds) are formed and properly deposited. We might go on now to examine cells containing many of these sub-

stances, but one or two examples will suffice. Perhaps the most familiar vegetable product is starch, certainly interesting since it enters so largely into the daily food of the world. Let us make a thin section of a common potato and examine it for a moment (Fig. 7). See what a multitude of tiny spheres and ellipsoids crowd the cells! If we apply to our section iodine, we introduce the test of color. The little solids take on a bright-blue tint, and so prove themselves

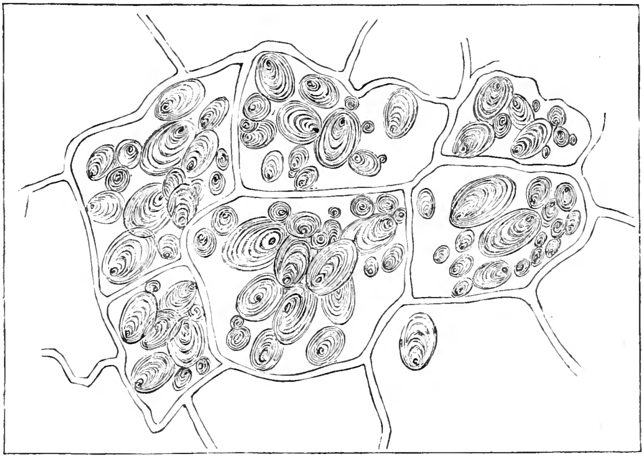


Fig. 7.—Potato-Cells, containing Starch-Grains.

starch. Now we can *see* why the potato forms so nutritious an article of diet. During fall and winter starch-grains, such as we have just seen, fill the cells of apple-twigs and of branches of various kinds, and form the basis for that lavish expenditure of plant-force by which our orchards and woods are made glorious in the sudden inflorescence of spring.

If we make a section of the petiole of a begonia-leaf, we may find cell-contents as remarkable as beautiful. Here are plainly crystals with their symmetrical, angular outline. Some of the mineral substances brought through the plant by currents ascending from the roots have found room in the cells of the leaf-stalk to shoot the rays of minute crystals, and here the crystals lie, sometimes a dozen jewels in a single setting (Fig. 8).

But the interest attaching to plant-cells does not culminate in chlorophyl, nor yet in starch-grains and crystals. The chlorophyl, as we have seen, owes its allegiance to the light, the starch to the chlorophyl, and the crystals to the water and the soil; but back of all this, and behind all this, though intimately united with it all, is that which owes its homage to none of these—which moves all, controls all, uses all, builds the cell-wall, and inhabits it—is, indeed, the active principle by which chlorophyl becomes efficient, by which the inorganic is lifted

into forms organic, and the earth filled with the children of life, the very essence of the living cell—the *protoplasm*. To this protoplasm we now turn our investigation.

Twelve or thirteen years ago this word—the name, to say nothing of the thing named—would have come all but unknown to the general reader. But to-day, thanks to the continuous discussions of the last decade, the word needs no introduction. All our readers know that

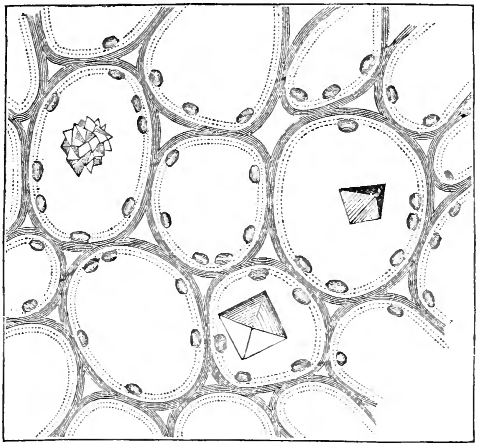


Fig. 8.—Cross-Section of Petiole of Begonia-Leaf, shows Crystals in the Cells (copied from Prantl.)

protoplasm is the simplest form of living matter with which we are acquainted, is the living element of every living cell. One of the most characteristic phenomena of life is independent motion, and protoplasm more frequently reveals itself by moving. Such is the case in the cells we are now considering. In 1869 Professor Huxley set the thinking world all agog by describing, in a passage of wonderful accuracy and beauty, what he could see of moving protoplasm in the hair of a stinging nettle. Nettle-hairs and vegetable hairs generally consist either of a single elongated cell, or of a series of oblong cells arranged in a filament. Moreover, such hairs, or *trichomes*, are usually colorless, transparent throughout, and afford, therefore, cells admirably adapted to microscopic examination. Hairy plants are very common, so we may corroborate Professor Huxley's statements by observations made almost anywhere. Let us examine a hair taken from the evening-primrose. Here, under a magnifying power of from 400 to 500 diameters, we may see within the hair a delicate current sweeping down one side to the point, turning abruptly with slight delay, and then returning by the opposite side of the cell, leaving in the center a neutral space filled with cell-sap, across which the oppositely moving streams seem never to pass, in which they are never lost. No nucleus is present, nor any central station of power. The tiny streamlet pours on, self-guided

(Fig. 9). The hairs on the young leaves of violets and on common red clover exhibit the same sort of a stream moving in much the same way (Figs. 10 and 11).

The unicellular hairs of the common morning-glory present a different phase of the same current. Here the stream is confined to the

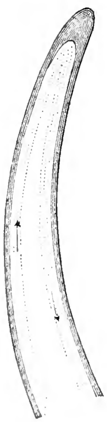


Fig. 9.—Tip of a Hair from Evening Primrose.

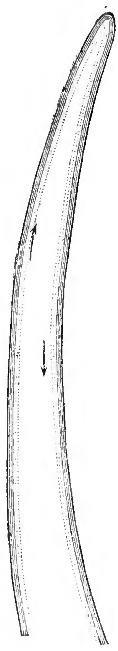


Fig. 10.—Tip of a Hair from Violet Leaf.

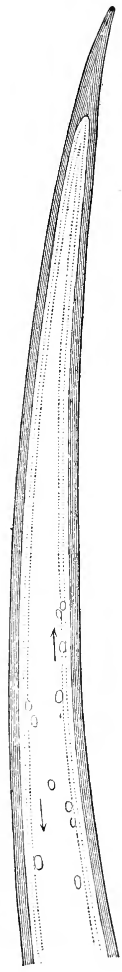


Fig. 11.—Hair from Red Clover.

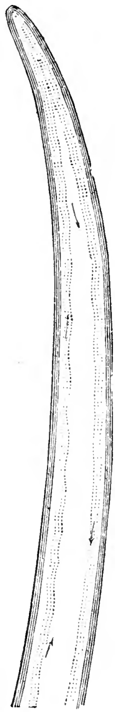
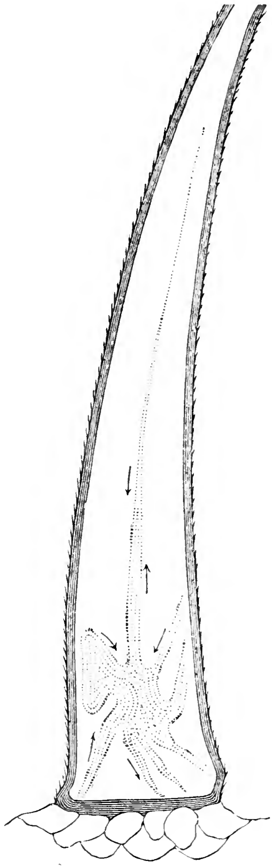


Fig. 12.—Hair from Morning Glory, unicellular.

cell-wall most closely, but the movement is unique. The protoplasm in its course is by turns contracted and expanded, giving to the whole current a billowy appearance, a miniature profile of rolling waters. Wave follows wave, but with no deceptive motion, for the rapidly passing granules advise us that the current is strong and real underneath waves that rise and fall but never break (Fig. 12).

The unicellular hairs found on young leaves of *Verbena urticifolia*, a common way-side weed, exhibit something like a nucleus at the base of the hair, from which center streams of protoplasm are constantly departing, to which they constantly return (Fig. 13). Fig. 14 shows the terminal cell of a hair taken from the petal of the purple lady's-



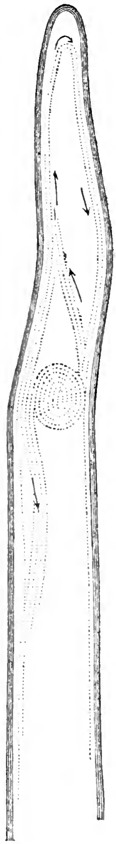


FIG. 13.—UNICELLULAR HAIR OF VERBENA. FIG. 14.—HAIR FROM PETAL OF LADY'S SLIPPER.

slipper. Here the nucleus seems almost to be in the way. It is so large as nearly to close the narrow cell across from side to side, and the current appears crowded between the nucleus and cell-wall.

In the hairs that cover the common tomato-plant we may find beautiful transparent cells. In these cells sometimes the nucleus shows a vacuole, and the streams are always fine and large, but changeful as the shadows of passing clouds (Fig. 15).

But we must resort to plants belonging to the botanical order *Cucurbitaceæ* to find hair-cells showing greatest activity. In the hairs covering the forming bud of a common pumpkin-vine the cells are of

rapid growth, with finely transparent walls (Fig. 16). Each cell has a large nucleus, which, while variable and varying, is quite constant in position, and often shows one or more vacuoles. Out to the very limits of the cell, sweeping its every corner from the nucleus as a center, vital streams go forth—streams now wide and sweeping, now narrowing and again swelling, or pouring along to join some neighboring current; now forming temporary vacuoles, now bearing on strong tide

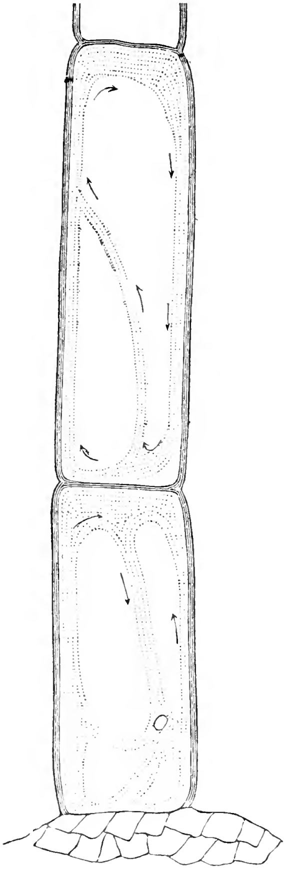


FIG. 15.—BASE-CELLS OF A TOMATO HAIR.

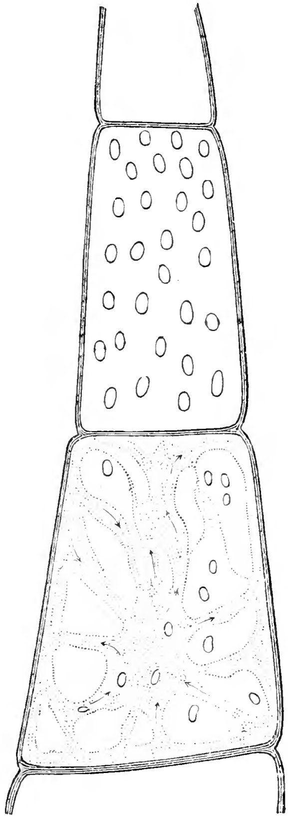


FIG. 16.—HAIR FROM PUMPKIN VINE.

particles large and small, granules of chlorophyl and what not; now branching in various directions, now diminishing to merest threads, forming and fading away, finally disappearing below the field of vision, only to reappear once more at the place of starting. The changes of movement and appearance are so rapid that no drawing can be true for more than a single moment.

In studies such as these we might pass on from plant to plant, in garden, on highways, in forest and on prairie, until time should fail and patience be well wearied. The "Song of Nature" is true:

"No numbers have counted my tallies,
No tribes my house can fill;
I sit by the shining fount of Life,
And pour the deluge still."

But there are some other plants whose cells exhibit the phenomenon of living, moving protoplasm so much better than nettle-hairs or pumpkin-hairs, that I can not forbear presenting, in concluding the present article, the cells of one more plant. The plant we now select is a very common one in most parts of our country, but on account of its simple and retired habits of life is little known save to the botanist and microscopist. An aquatic plant it is, finding a home in slow-running streams, or shallow ponds whose sandy bottoms reflect the warm rays of the summer sun. Totally immersed in water, however, and so far independent of rains, our plant knows little distinction of spring and summer, and grows on vigorously until the frosts of fall are heavy enough to seal everything under a covering of ice. If during this long, growing season we collect a sprig of *Chara* (for such is the name of the plant), we shall find it made up of something like a stem bearing whorls of leaves, or at least of what may pass for leaves. Let us now take one of the newest and smallest of these leaves and place it under our lens. A series of cells, you say. But through the thin wall of any cell appears again a flowing stream. Not the pale, delicate thread of silver we saw feeling its way around the cell-wall of the pumpkin-hair or tomato-hair, but a very river it seems now as it rushes on, wave after wave, up from the depths below across the field of vision and down again, over and over, or round and round, in ceaseless rotation (Fig. 17).

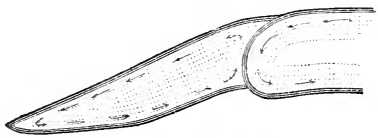


FIG. 17.—TERMINAL CELL FROM A FROND OF CHARA (slightly magnified).

Now the current catches in its course this little particle, now that, hurling each along, now up, now down, now over, now under, without weariness, without hindrance, hour after hour, before us.

And now, as the stream goes on so grandly, think, for a moment, what it is at which we gaze. We call it protoplasm, but it is the current of life, the "physical basis of life"—the common bond which binds in one the whole kingdom of organic things. Think, too, of the antiquity of that stream, its lineage. The brook that "goes on for ever" is as nothing to it, for here the stream has come flowing down through ages which are to us as eternity, ever since life began on earth. The mountains have been hoary with years, and have disappeared beneath the level of the all-producing sea, but this stream is older than they. Continents have grown old, worn out, and been re-

newed, rebuilt from the *débris* of this same stream, and life has again flooded the continents, but its origin is older than they.

But now that we have before us such a fine large stream, may we not make further investigation, may we not know its mystery, the hiding-place of its power? We touch the cell with our needles, open its wall to make minuter inspection; but in an instant the charm is broken, the mystic river forgets to flow, the tiny particles settle into unbroken peace.

> "The parent fountains sink away
> And close their crystal veins;
> And where the glittering current flowed,
> The dust alone remains."

We are permitted to look in and see how the work of life goes on, but we can as yet go no further. We may explain. We may say it is all the result of chemical forces, and doubtless chemical forces are working there; but such explanation demands an explanation. Does chemical action renew itself? Chemical action is one thing, chemical action perpetuated and controlled by life is quite another. We may say, life is the property of protoplasm, or we may reverse the statement and say that protoplasm is that form of matter which manifests the phenomena of life, but that is as far as we can go. The streamlet hemmed by the narrow walls of the cell of any plant is to us a boundary. On one side the line, peace unbroken, eternal fixity, rest, of a world whose chemical forces acted once and for ever; on the other, the vast procession of life begins, rises before us, spreads away in variety, activity, in beauty, in wonderfulness, incomprehensible.

THE JEWS IN EUROPE.*

By Dr. J. VON DÖLLINGER.

II.

A GLANCE at the changing fortunes of the Jews in France, England, and Spain, brings clearly to light how their condition was influenced by the hierarchy. In England as in Germany, the Jews were the special property of the king, and were in part fostered as a valuable and profitable possession, and provided with privileges, and in part, particularly under King John and Henry III, made the object of merciless extortion. They enjoyed, indeed, also the royal protection, which, however, in times of sudden attack by the populace, came almost always too late, and only sharpened the popular hatred to which

* Anniversary Address before the Academy of Sciences at Munich, delivered July 25, 1881. Translated by Mr. W. M. Salter.

they fell a prey. Henry III, after forcibly assessing them several times, took (in 1230) suddenly from them a third of their possessions; afterward, to get a loan, he mortgaged all the Jews of Great Britain to Count Richard. The Jews begged, since their condition had become unendurable, for permission to emigrate; but it was refused them, since the king loved them all too dearly to let them go. Bishops, as Grossetete, of Lincoln, demanded their banishment, and Edward I ordered it in 1290; and in this way robbed himself of a most valuable instrument, by which previous kings had indirectly taxed their subjects. On account of the general lack of regular and sufficient income for the crown—a lack under which all states at that time suffered—some persons must be found who would take the place of those who had been banished. Such substitutes presented themselves in the associations of the Caorsines and the Italian money-brokers. Their way to England was paved by the Roman curia, which used them as its collectors, though the most prominent of them became bankrupt suddenly in 1345, and went off with debts unpaid. As usurers and financial managers for the crown, they were hated no less than the Jews.

In France the system of extortion practiced upon the Jews was still more methodical and crafty. Philip Augustus began his reign at the age of fifteen (1182) with the plundering and banishing of all Israelites. The report that they put a Christian to death every year at the time of their passover is said to have led him to this course, but the debts left him by his father were the immediate occasion. In the year 1198 they were recalled. Louis VIII declared all their claims for interest to be invalid, and ordered that the moneys due them should be paid to their lords, the king and the barons. Louis IX, convinced equally that all taking of interest was heinous sin, and that all the Jews of the land were his slaves, compelled them several times to purchase the privilege of remaining in the country; and, when he thought that he had extorted enough from them, banished them from his kingdom, with confiscation of whatsoever they still possessed. When the Jews implored before the governor of Narbonne for the restoration of the rights that had been taken away from them by the king, they complained: "The Jews are robbed of their means, and yet compelled to pay their debts; while, on the other hand, those who owe them are freed from the obligation to pay their Jewish creditors. They are forbidden to loan money on interest, and yet are not allowed to earn a living in any other way." The king's order was not completely carried out. Many remained, others returned afterward from time to time.

Louis's brother, Count Alphonse of Poictiers, made use of a particularly shrewd procedure in his state, which was afterward imitated in Germany. Under the pretext of expenditure for a crusade, he had himself authorized by the Pope to appropriate to himself all interest

that had been collected by the Jews; and then the entire Jewish population, including women and children, was incarcerated. The poorer ones were liberated after a while; but the rich, with their wives, were held in prison until they had completely satisfied the avarice of the count and his officials. Philip the Fair did not fail to follow the example of his grandfather, in a way that was even more thorough, and brought more profit. He banished suddenly all Jews in the year 1306; possessed himself of their entire property; had their houses, synagogues, schools, and even their burying-grounds, sold to the highest bidders; and compelled all their debtors to pay into his own treasury. With the barons, who craved their share in the spoils, he came to an agreement.

The drama closed at last in the year 1394 when Charles VI, on the representation of his confessor, and at the request of his spouse, who was under this man's influence, ordered the last expulsion of the Jews from his kingdom, on the plea that many who had intercourse with them had become lukewarm (*tepidi*) in their faith.

In Spain, under Mohammedan rule, the condition of the hunted and afflicted people was more favorable than in any Christian land. Although not free, the synagogue chose its own national judges or kings to represent it before those in power. Their schools flourished there; they pursued especially the study of medicine with greater success than the Christians. Also under the Christian kings in the twelfth and thirteenth centuries they were still influential, serving the kings as financial advisers, chancellors of the exchequer, as astronomers and physicians. In Toledo alone there were some twelve thousand of them; their wealth permitted them to purchase at least the most indispensable rights by the expenditure of money. In general, from the time of the Arabian rule to the end of the thirteenth century, their condition in Spain was more favorable than in any other European land. Within the walls of their Jewish quarters (*aljamas*), they lived according to their own law and statute. But the fourteenth century brought evil in its train also to the Jews of the Peninsula. While valuable and serviceable to the kings as farmers of the taxes and chancellors of the exchequer, they were hated by the people. Now in one city, and now in another, they were attacked, struck down, and their synagogues burned. The most violent storm broke upon them in the year 1391, and raged throughout the whole of Spain; priests, like the Archdeacon of Ecija, had kindled the conflagration by their sermons. Many thousands were slain; 200,000 saved themselves by baptism, but after a few years it was found that 17,000 had relapsed into Judaism. A hundred years later—1492—the royal edict appeared which commanded the entire body of the Jews to emigrate, and leave their possessions behind them. Since the Inquisition at the same time forbade selling food to the Jews, the majority were not able to emigrate, if they wished, and so were compelled to be baptized. The most of

those who went out of the land—the numbers vary from 170,000 to 400,000—perished by plague, famine, or shipwreck. The descendants of the survivors, the Sephardim, found reception in Italy and in that part of the Orient which was under Turkish dominion; also for a short time in Portugal. Spain, however, became filled with families of mixed descent, and the contrasts of pure and impure blood, of old Christians and neo-Christians, poisoned the whole social life.

The fate of the Jews was still worse in Portugal than in Spain. For a long time their condition was better than in the rest of the Peninsula. The murderous storm of 1391 did not extend to them; they enjoyed some privileges, had property in land, and pursued agriculture and wholesale businesses. But in the reign of King Manuel (1495), otherwise praised as gentle and humane, they met with a deadly blow: their children under fourteen years were snatched from them and baptized; they themselves could remain in the land only as they became converted to the Church. Thus this kingdom also was filled with those who feigned conversion and were forcibly baptized. The results were fearful. In the year 1506, in Lisbon, two thousand new converts were put to death in three days, because one of the neo-Christians had ventured to doubt a supposed miracle. Soon after, the Inquisition was introduced as the well-tried instrument for handing over the property of the wealthy neo-Christians to the state treasury.

In the larger commercial cities of Italy, the existence of the Jews was, comparatively speaking, endurable. Since the trade in money was already in the hands of Christian bankers, they occupied themselves more here with mercantile business. They encountered no risings of the mob, or massacres.

All these things become more comprehensible when we observe that the historians of the time, in narrating the enormities that were committed, give no sign of pity, and do not utter a word of indignation. Many times the clerical chroniclers even express their satisfaction: for example, the Monk of Waverley writes in a triumphant tone of the massacre, in London, at the coronation of Richard I, which was perpetrated without any provocation on the part of the Jews, and closes with the exclamation, "Blessed be the Lord, who has given up the godless to their deserts!" ("Annales Monast.," p. 246). And yet they do not fail to point out that avarice was a principal cause of these misdeeds; that nobles and citizens who were in debt incited to them, in order, by a single stroke, to become free of their (Jewish) creditors; for money was in truth the protecting as well as the destroying angel of the Jews in those days. The unhappy ones must press their debtors, always expecting that at the next moment they themselves would suffer from the inevitable reaction against them.

Since the clergy declared the mere existence of the Jews among the Christians to be an immeasurable danger, requiring the most careful watching and isolating, we should expect that they would have

labored conscientiously and with all their powers to convert the Jews. This did not happen, however. The men who were capacitated for such a work were completely wanting until the beginning of the thirteenth century, and even after the rise of the mendicant orders, a part of whose work was to institute missions among the Jews, there was very seldom a theologian who could lay claim to the education indispensable to this end. An interpretation of the prophetical books (of the Old Testament), which could have made an impression upon educated Jews, was beyond the powers of that time. That great flood of allegorical interpretations, which ruled the Biblical literature of the Christians, appeared to Israelitish Biblical scholars the empty play of an arbitrary and unbridled imagination. The early Church stood, in general, much nearer to the Old Testament people and faith; the great alterations and new formations of the middle ages had immeasurably widened the gap. The worship of images, which, according to the Israelitish view, contradicted the Decalogue, the whole scheme of dominion and compulsion which had been organized by Hildebrand, the religious wars with the system of indulgences—these were things that made the conversion of a Jew uncommonly difficult; and the pictorial representations of the Trinity, that appeared in the latter part of the middle age, must have seemed like a confirmation of the charges of tritheism which they brought against the Christians. In many places, indeed, the Jews were compelled to hear discourses aiming at their conversion by the monks, but an effect opposite to what was intended was unavoidably produced. It is told of the preacher-monk Vincenz Ferrer, that his eloquence effected 30,000 conversions in Spain. But these ostensible conversions took place in the midst of the horrors of the slaughter of 1391 and of the ensuing occurrences, and the apostasy that soon commenced of 17,000 new converts indicates how much the conversions were worth.

If a Jew voluntarily became a Christian, he lost everything that union with a people holding so firmly and faithfully together had hitherto secured him, and by no means did he win the favor of the Christians; rather did his condition in most cases become worse. For the Church met him with suspicion. In Rome, indeed, it was regarded as a rule, to which there was hardly any exception, that a baptized Jew would relapse. If he had means, it was made a duty for him to return all the interest he had taken, a sum often in excess of his present possessions; and in France it was even the custom to confiscate all his goods, and indemnify the king or baron for his loss of a bondsman, and of the income derived from him. Two laws of Charles VII destroyed this custom; but this very monarch took from the Jews, who avoided exile by embracing Christianity, two thirds of their property for himself; and his contemporaries thought this a softening of the severity of the old statutes. If the converted Jew was poor, he experienced the lack of the means of subsistence; for he had not learned

a trade, nor could he any more take up with traffic in money, and his only resource was to become a barterer and dealer in small wares. The worst and most horrible thing was that the new convert fell a prey to the power of the Court of Inquisition, and, wherever there was an inquisitor, he was liable to arrest and torture on a mere suspicion, and could be sentenced either to money-fines or to imprisonment. That the inquisitor could impose fines upon merely suspected persons was already, in 1330, the teaching of the canonical writers, and nothing was easier or more tempting than the discovery of some cause of suspicion against a rich Israelite, baptized or unbaptized.

While the Spaniards were striving to root out Israel from the Peninsula, they prepared for themselves a most fearful scourge, under whose lashes they were to bleed for centuries. For, since they drove so many Jews into the Church through fear of death, and forced them to continuous hypocrisy, they caused the establishment of the Holy Office, which was directed at first against this secret retention of the Jewish faith. The majority of educated Spaniards at the present day doubtless acknowledge the Inquisition to have been the sorest national misfortune; it was an institution which has served to dishonor the Spanish name, and has been a source of manifold misery and a school of hypocrisy to the Spanish people. But that this institution maintained itself so long in Spain, and for over two hundred years found continually new victims for its "acts of faith," is owing to the events of 1328, 1391, and 1492, along with the distinction, contrived by the Church, between absolute and relative coercion in baptism.

Many thousands of Jews were then forced to be baptized; they were often allowed no other alternative than that of death or entrance into the Church. In many cases they preferred death, and perished either by their own hands or at the hands of their oppressors, and the example of some who were steadfast inspired whole hosts to copy after them. At the same time, there was a considerable number who, in fear of death, or to escape banishment and loss of property, suffered themselves to be baptized; and it was just as natural that, when they breathed free again, they should renounce Christianity and turn back to the cult of their fathers.

The doctrine was indeed continuously taught and accepted that a baptism forced upon one was null and invalid, and it would hence seem self-evident that he who had been coerced should be free to turn back to his ancestral religion. But, as early as 633, the Spanish Visigothic bishops had declared that those forcibly baptized should be held in the Church. This had passed over into Gratian's book of doctrines and statutes, and now no one was any longer permitted to surrender the Christian faith once confessed, or return to the practices of Judaism. He was once for all a Christian, and, as such, subject to the jurisdiction of the religious court; if he went back to the faith of his fathers he must suffer, as every heretic and apostate, the death

by fire. The princes were also ready, in case no Court of Inquisition was in existence, to execute this punishment. The Emperor Frederick III caused a young man, who was valuable to him as a servant, and who, after being baptized out of fear turned back to Judaism, to be conducted to the stake, to which he went singing psalms. In Spain and Portugal the observing of some Jewish rite, on the part of a new convert, sufficed to subject him to imprisonment and torture. It was not realized that by this means the Church was being filled with hypocrites, and that numberless profanations, otherwise sought to be avoided in every possible way, unavoidably took place. In her better days the Church regarded an entrance of her walls, accomplished by the influence of slaughter and terror, a disgrace and a sacrilege; but now all, bishops, priests, and laity, worked harmoniously together to imprint this stigma on their Church—above all, in Spain.

A more painful existence than that of a Jew in the middle ages is scarcely thinkable, and, if he had had a knowledge of history, with what longing would he have looked back to the happy time of the Roman Empire! Every day the Jew must be prepared for some act of extortion, or the loss of all his goods, or imprisonment or banishment. Emigration was often impossible, and was in most cases not permitted, so long as the Jew had any remaining possessions which could be taken from him; and when he did undertake it his condition hardly ever improved; it was often "falling out of the frying-pan into the fire." Moreover, he had to pay a high price for permission to live elsewhere, even if it was only for a few years. On the highways of the country his person was as insecure as that of an outlaw.

The whole external history of the Jews for almost a thousand years makes up a succession of elaborate oppressions, of degrading and demoralizing afflictions, of violence and persecution, of wholesale slaughters, with interchanges of banishments and recallings. It is as if the European nations had vied with each other in trying to create the double delusion that the Jews were condemned till the end of time in the decrees of Heaven to the severest helotism, and that the sons of the Gentiles were ordained to act the part of jailers and hangmen to the chosen people of God! Christians knew not how to dispense with them; they were serviceable in many ways; and yet they could not be endured. Their countenances worked like a challenge upon the believer, who was touched by no scruple, and thought it possible to explain the Jews' fixed attachment to their ancestral faith, under the clear light of the gospel, only as a species of wicked obstinacy.

Nevertheless, one feature is striking in the great mass of abusive discourses, arraignments, and declamatory outbursts against the detested people—a feature which, along with endless repetition of the customary phrases, characterizes the ecclesiastical literature of those centuries: and this is, that their moral life, so far as the family, chastity, temperance, and fidelity to obligations go, is never attacked. Along

with the charge of avarice and usurious money-lending, it is always simply their religious belief that made the ground for charges against them: they are continually accused of crime; and the fact that they did not recognize the Christian doctrines of the Trinity and Incarnation was sufficient proof of their guilt. That they actually railed at Christ and his mother before the ears of Christians was certainly very rare, since they knew that a word of that sort sufficed to devote them, and often also their families, to death. It could not occur to an Israelite to wish to convert a Christian to his own faith. It is written in the Talmud, "Proselytes are as dangerous for Judaism as ulcers on a sound body." If one not a Jew had really a mind to become a convert to Judaism, he must be told, "Do you not know that the Jews live in sufferings and woes, that they are insulted and cast out, tormented and put to the rack?" At the same time, he was reminded of the oppressiveness of the statutes, and of the privations and sacrifices to which he would have to submit.

"The Christian brought the Jews to this pass," Shakespeare makes his "Merchant of Venice" say, and history for thirteen hundred years says the same. When the Jews in Spain were threatened with destruction and banishment, a rabbi is reported to have said to the Christian: "We are at once a people blessed and laden with a curse. Now you wish to destroy us, but you will not succeed, because we are blessed. The time will come when you will exert yourselves to raise us up, but in this you will not be successful, for we are cursed." If this was actually uttered, it is not clear whether the reference was to the Spanish Jews, the Sephardim, or the curse was conjectured to rest on the whole people. A retrospect of nine centuries of ignominious treatment and misery might easily have awakened such a thought. But since the Reformation the lot of the Jews has been steadily growing more favorable, and to-day no rabbi can any longer have the sense of a curse resting upon his race. The number of Jews now living on the surface of the globe has been estimated to be very nearly twelve million; should the number be less, it is none the less certain that they are more powerful than they ever were in past time, not excepting the period of their political independence. The official (Christian) interpretation of the word of the prophets, current in the middle ages, is thereby proved delusive; according to it, the Jewish people were to be reduced by continuous mistreatment and persecution to a very small handful of survivors. But in spite of all the heavy blows dealt upon this anvil, and of the numerous proselytes to Christianity and Mohammedanism, they have not lost but rather steadily increased in numbers. For a hundred years Israel has struggled for political emancipation, and at last has won it in all European states; only Russia, Spain, and Portugal have not as yet granted it. It has also not been granted them in the Mohammedan world. But in Europe the larger half of the Jews find themselves in possession of all social and political rights.

Israelites sit now in the parliaments and congresses. They are allowed to be teachers in most of the universities, and the number of Jewish young men who devote themselves to study increases with every year. Important offices are already intrusted to Jews. Their protective union, the judiciously managed "Israelitish Alliance," which has its seat in Paris, appears to be constantly winning greater influence. The facts of comparative statistical science are favorable to them. In most countries, theirs is, relatively speaking, the smallest number of judicial crimes, and they stand foremost among the population in general prosperity and wealth, even in length of life and rate of increase. The old virtues of temperance and continence, of well-ordered and affectionate family life, of filial piety to parents, which served so well in preserving this people from destruction in the troublous times of the middle ages, have not yet vanished from among them. Marriage unions with Christians and conversion are more common than formerly; in Berlin alone several years ago, there were estimated to be some two thousand proselytes.

It is true, however, that there are dark shadows to the picture; the better spokesmen of this people do not deny their serious faults; they must allow that there is abundant occasion for sharply reproving them: they only urge that the faults arrest attention more than the virtues. The strongest charge and the principal reason for the popular hatred of them is the economical injury they inflict, and the manner in which they take advantage of the peasantry in the Slavic and also in some German countries, in connection with small bartering and money-lending, which seem to be their favorite occupations. In the East, particularly in Galicia, this injury is called even by a stronger word—it is named devastation. The fault is undeniable; our Israelitish fellow-citizens lament it as much as we, but it would be unjust to make, on account of race connection, the whole responsible for the conduct of a fractional part, who are far removed and beyond control. The same is true of the founding of sham companies (Gründerunwesen) and the pernicious speculation in money, which is a fault common to Christians and Israelites. As it was formerly alchemists, astrologers, and searchers after hidden treasures, who took advantage of the blind and eager credulity of the higher classes, so now Jewish speculators do the same. In a similar way, the sins of the press of the day are to be charged upon its circle of Christian readers as well as upon the Jewish editors, who only follow the fashion in pandering to, rather than trying to mold, the opinions and passions of the people.

The great reform movement, that began with Mendelssohn in the bosom of Judaism, has given it a new form in Germany, France, and England. Those of the Jewish people who live in Slavic countries remain for the most part untouched by this movement, and are still bound to the Talmudic standards; but in Western Europe the Israel-

ites have given up many of their traditional prejudices and customs, and come nearer the Christians in manners and ways of thinking.

At the present time, Germany is the bearer and foster-father of the spiritual life of Judaism, as in earlier times (and in the order stated) were Spain, Southern and Northern France, and then Holland. The German Israelites lead those of the rest of the world, because of the language they use; they alone, too, have a religious and theological literature of their own, to which their brethren in other countries resort for instruction in spiritual things. And hence it may be justly asserted that the influence of German ways of thinking is stronger than any other one thing among the Jews to-day, and it extends even to North America.

Among civilized peoples with a distinctive moral and intellectual life, the Jew residing in their midst thinks with the bulk of the nation. The German Jew thinks about all questions of spiritual and social life in an essentially German manner, which was far from being the case in the preceding century; and since our culture and civilization have come out of Christianity and have a Christian coloring, the Jew, however disinclined he may be to Christian views, can not help thinking and acting about many things, whether consciously or unconsciously, in a Christian way. So, for example, in regard to marriage, which is regarded by the Jews no longer from the Old Testament point of view, but from the Christian. And the same may be said of the British and French Israelites; they think and feel as the great nation thinks and feels in whose midst they live.

Altogether too long has the false and detestable view ruled in the world that we are called upon to avenge, generation after generation, the sins and mistakes of the fathers upon their guiltless descendants. It is a view which has covered Europe with a multitude of cruel and shameful deeds, the thought of which causes us to shudder and avert our faces. Woe to us and our posterity if such a law of revenge is ever applied to the descendants of the Germans, Frenchmen, Spaniards, and Englishmen of the middle ages! But there is one thing which the self-styled anti-Semitic agitation of to-day should not forget, viz., that hate and contempt are feelings bitter and of no comfort to him who cherishes them, and painful and exasperating to those against whom they are directed. A sad thing it is when (to use a Scriptural expression),

"Deep calleth unto deep."

Rather let the saying of Sophocles's "Antigone" be and remain our motto:

"My nature leads to sharing love, not hate"

PORCELAIN AND THE ART OF ITS PRODUCTION.

By CHARLES LAUTH,

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THE uses of porcelain have so multiplied, the employment of that material has become so general, that few persons recollect the time, not yet far back, when it was considered an object of luxury, and only delf was within the reach of all. In this paper I shall consider, first, the nature of porcelain and the history of its discovery; next, the principal points in its manufacture; and, lastly, the different methods of decorating it.

It is generally understood that porcelain is, as a rule, the resultant of the action of fire on a certain kind of clay. No one is likely to confound it with earthenware or delf. While those wares are soft, opaque, and of impure colors, porcelain is always white, is perfectly clear, and is harder than steel. The fundamental distinction between the three wares is that earthenware is obtained by the simple action of fire on common clays; delfs are earthenwares more or less colored and glazed with a leaden enamel, which is rendered opaque by tin; while hard porcelain is obtained from a white clay, kaolin, and is enameled with feldspar.

Kaolin, a natural hydrated silicate of alumina, is absolutely refractory and opaque; it constitutes the resistant part of porcelain. Feldspars are silicates of alumina and potassa, fusible at a very high temperature into a beautiful transparent glass. If, now, we mix a quantity of feldspar with kaolin, cover the mixture with a layer of feldspar, and heat the whole at a very high temperature, the feldspar will melt and communicate to the opaque clay a clearness greater or less according to the quantity of it present, and to the superficial part of it that beautiful glaze with which all are familiar. A part of the action in this process is chemical, and consists in the production of a new crystalline silicate formed by a combination of all the substances present. The discovery of porcelain in China is traced back to a high antiquity. The Chinese have certainly made it regularly for at least a thousand years; many authors fix the discovery at fifteen hundred or eighteen hundred years ago, but no evidence exists to justify our going further back than a thousand years. The first pieces that came to Europe were probably brought by the Venetians at the end of the thirteenth century. Charles VII, King of France, received a present of Chinese porcelains, about the middle of the fifteenth century, from the Sultan of Babylon; but it was not till the sixteenth century that the importation of these Oriental products by Portuguese and Dutch merchants assumed a real importance. The discovery of tender porcelain was made in France toward the end of the seventeenth century, but

whether by Louis Poterat or by Reverend, at Paris or Rouen, is disputed. This ware has no relation with real porcelain ; it contains neither kaolin nor feldspar, but is an artificial product, a kind of glass made from a mixture composed essentially of sand, lime, potash, soda, and a small quantity of marine marl. This mixture, made plastic by the addition of manganese or other fluxes, is baked without glazing, and is covered after baking with a glazing composed of silica, lead, potash, and soda. The beauty of the material, its perfect glaze, and the facility with which vitrifiable colors are fixed in it, make of tender porcelain a ware exceptionally adapted to decoration.

The discovery of tender porcelain did not arrest the investigations of men of science and potters, who saw very well that it had none of the characters of the porcelain of China. A bed of kaolin was found in Saxony in 1709, and Böttger set up at Meissen the first European factory of hard porcelain. Fifty years later, in 1758, Guettard at Alençon, and afterward, in 1769, Madame Darnet at Saint-Yeux, near Limoges, discovered the French beds, and the industrial fabrication of hard porcelain was begun in France in 1774. Tender porcelain gave way quickly in the rivalry with hard porcelain. This was unfortunate, in an artistic point of view, for the latter material is very unaccommodating to the decorator. A more important object was, however, to create for domestic economy an absolutely healthful industry, and much is due to the illustrious Brongniart for having by his investigations put the manufacture of kaolinic porcelain on a firm scientific foundation.

Natural kaolin is never a pure clay, but contains also sand, undecomposed feldspar, etc., in variable quantities, and must first be purified. For this purpose the mass is pounded, and the products are separated one after another by successive levigations with water. The clay, which is extremely slow in settling, is drawn off first, and may be obtained almost pure ; the other deposits, composed of more or less feldspathic sands, are brayed in mills, and are destined to enter in their turn into the preparation of the pastes. The nature of porcelain, its physical and chemical properties, vary infinitely according to the proportion of its two consituent elements (kaolin and feldspar), and as other substances, lime, silicious sands, potsherds, etc., are added, as is often done. Every country and every factory has its composition, which is adapted to the use to which the porcelain is destined, to the degree of resistance that is to be demanded of it, and to the kind of decoration it is to receive. Generally, porcelain is more solid as the proportion of clay increases, and requires a higher temperature in baking ; if, on the other hand, the proportion of feldspar is increased, it becomes more fusible, may be baked at a lower temperature, and submits more readily to decoration, but its plasticity and the possibility of working it easily diminish rapidly. The mixture of the materials should be perfect ; when this is the case, the mass will keep for a long time, and become

more plastic as it grows older. The qualities required of a good paste may be communicated by diluting it and stirring it with water and decanting, or by prolonged beating and manipulation. By treading it out or beating it we not only give it complete plasticity and homogeneity, but we also clear it of air-bubbles which would otherwise swell out in baking and cause much damage.

The next thing is to give our ware the form which has been determined for it in a design previously made. This requires a knowledge of the whole process of fabrication. It would be a mistake to suppose that porcelain can be baked in any desired form. It becomes soft in baking, and has to be supported; and, as it is to be covered with a glass that melts at the same moment, places which need not be enameled must be found for fixing the supports in every piece, unless we are willing to risk having it spoiled. We may thus comprehend one of the difficulties in the manufacture of porcelain, and one of the points in which it differs most from delf.

Articles of porcelain may be shaped without molds or with them. By the former method all the shapes are obtained that may be produced by turning. The clay is first shaped on the wheel by the hand into a rough block of the general shape which the object is destined to assume, and is then left to dry, slowly and with care, to keep it from cracking. When it has been dried to a suitable degree of consistency, it is put upon the wheel again and carefully worked into the exact shape desired, with the moldings and ornaments called for by the design, and by the aid of the most simple instruments.

Articles whose shape does not adapt them to manipulation on a revolving wheel, such as objects of statuary and many lighter objects, may be shaped by molding them. The mold is made of plaster of Paris; to it, when dry, is applied a layer of the porcelain paste, which is pressed into it carefully and as evenly as possible; the earth espouses all the details of the sculpture, and, after a few moments, the plaster having absorbed the water from the paste in contact with it, a shrinkage takes place, thanks to which the proof detaches itself almost spontaneously. The operation is sure to be successful in the case of simple forms whose outlines offer no impediment to taking them from the molds. If, however, we purpose to obtain objects in relief, statuettes, groups of figures, or sumptuous vases, the sculptural decorations of which constitute their chief ornament, the process becomes more complicated. In this case the molder has to divide his pattern into a number of parts, the superficies of which must be determined by the possibilities of taking off the molds; then he must make as many molds in plaster as he has parts of his model; these molds will in their turn serve for the reproduction of each of the parts, which have afterward to be joined and cemented by the aid of the paste diluted in water. After this the seams at the junction of the parts must be rubbed away, and the whole work finished up by a restorer who must

necessarily be an artist. I can not leave this part of my subject without mentioning the property which porcelain has of shrinking when baked. The shrinkage amounts to about ten or fifteen per cent.

A third method of shaping porcelains is by casting, which was discovered at Tournay, 1784, and in which Brongniart has made numerous improvements. Nothing is more simple than the manufacture of a small object by this process. Thus, if we take a plaster mold of a cup, and pour into it a quantity of barbotine, or porcelain-clay mixed with water, the mold will absorb the water from the clay in contact with it, forming a shell less liquid than the rest of the barbotine, and which sticks to the plaster. When this shell has attained a suitable thickness, the rest of the barbotine may be poured out: what remains in the mold constitutes the cup. We leave it to dry, and in a little while it will have gained consistency enough to be taken out of the mold without being deformed. Ware thus made is extremely delicate; the slightest pressure with the fingers may destroy it. This process is used at Sèvres for large pieces, but special manipulations are required for such work; for the weight of the shell which should adhere to the mold when the liquid is poured out, and which should be thicker and heavier in proportion to the greater size of the vessel, is very apt to cause it to separate from the plaster and fall. The least awkwardness might destroy the piece, and this should be avoided at any cost. MM. Milet and Delacour have devised a method, which has been used at Sèvres since 1857, for avoiding such accidents by turning compressed air against the interior of the mold at the moment the barbotine is poured out, to take the place of the liquid and hold the porcelain shell against the plaster. M. Regnault has simplified this operation by exhausting the air on the outside of the mold, which effects the same purpose and is more convenient of execution. The absence of seams, the purity of the outlines, and the clearness of the surfaces obtained by this process, make it one of inestimable value when we wish to get an object of art, and lift it far above the process of molding. The details of the operation are very exacting, but none of them should be neglected. Their importance may be realized by reflecting that a hidden fault in the interior of a large piece, a bubble of inclosed air, a lack of homogeneity in the paste, or other flaw, is not perceptible till after the baking, when the vessel has been decorated, and may perhaps have become of very great value. The slightest defect in the casting may destroy this value.

The objects, having been properly shaped and fitted, have next to be transformed into porcelain by the action of fire, the function of which is to combine the different elements of the paste and determine the fusion of the glazing. The baking is done twice. In the first operation, when the temperature is relatively only moderately high (1,800° to 2,160°), the earth is converted into what is called biscuit-baked porcelain; it becomes very tough and sonorous, and extremely

flexible; in this condition it is submitted to the enameling process. That operation is of the simplest character, and consists in a quick immersion in water holding in suspension a feldspathic rock, which has previously been reduced to an impalpable powder. Yet it requires great care, for the thickness of the enamel must be adapted to the piece; it may be neither too great nor too little, under penalty of accidents; it must be as even as possible, with neither bulges nor thin places. These qualities can not be obtained by dipping alone, so the object has to be retouched with a brush. The next step is baking in the sharp-fire, where the temperature of from 2,880° to 3,240°, at which feldspar fuses, must be reached. A few facts will enable us to comprehend the steps and the difficulties of this operation. Porcelain-clay can not be baked in direct contact with the flames, ashes, and smoke, without being greatly altered. It must, then, for the biscuit-baking as well as for the sharp-fire, be inclosed in protecting envelopes called *gazettes*, or *casettes*—cases of as refractory clay as can be got, in which the pieces are adjusted with great care on suitably arranged supports. It must be remembered that porcelain is baked at the temperature at which it becomes soft; the softening must then be anticipated at the time of fitting the vessel in the *casette*, and all the parts of the object must be supported so as to prevent any possible deformation. At the same time the supports must be prevented from sticking to the piece; and it is only by the aid of many kinds of artifices that the object can be effected without the supports leaving visible marks of their having been applied.

The furnace is divided into two stories, the upper one of which is the dome, or biscuit-baking compartment, and is warmed by the surplus heat that escapes from the lower story and passes through the vent-holes in its roof. The lower story, where the baking with the sharp-fire is done, is called the laboratory, and is heated by a number of fires placed along the circumference of the furnace, called *alandiers*. The *casettes* filled with articles to be baked are arranged vertically and as symmetrically as possible, and properly supported in the interior of the laboratory; when the furnace is filled, the entrance is closed by a double door of refractory materials, and the fires are kindled at the different *alandiers*. The temperature should be raised very slowly and very regularly, in order to avoid unequal dilatations, which would develop breaks in the objects. The heating is watched through little openings left in the walls of the furnace for that purpose, through which the color of the fire is observed. It may be seen to pass in succession from a dark red to orange, bright orange, and white. At the white heat, which is reached in from twenty-four to sixty hours, according to the kind of furnace and fire, the porcelain is near its baking-point. Since no apparatus has yet been invented for ascertaining the precise temperature within the furnace, the condition of affairs inside has to be determined experimentally by means of trial-pieces, which are

put in for that purpose. These pieces become glassy a few hours before the baking is completed, but are apt in that condition to fly to pieces. If the baking is arrested at that point, the pieces would all be excessively brittle, and the batch would be spoiled; so the heat is kept up till the trial-pieces come out glazed and clear, without being brittle; but, if the cooking is prolonged much beyond that point, it will be at the risk of changing the character of the porcelain, and of other serious accidents. It is a very delicate matter to determine the right point for stopping the heat without running upon one danger in the effort to avoid the other. When the cooking has been judged complete, the fire is covered up, the vents are stopped, and the furnace is left to cool of itself—a process requiring from four to eight days.

An equally important consideration with that of the temperature is that of the nature of the gases existing within the furnace. If only white porcelain is baked, it is generally best to have an atmosphere of reducing properties, because the small quantities of iron, titanium, etc., included in the clays, will then be least oxidized, and will not color the mass as would be done with an oxidizing flame; if, however, the porcelain is decorated, it is generally an advantage to have an oxidizing atmosphere; and, as both kinds are generally baked at once, it is only by the best management—by, for example, artificially introducing into the piles gaseous substances adapted to one or the other object—that a satisfactory result can be reached. The nature of the fuel employed is variable. Different kinds of wood and coal are used. Efforts are made to adopt gaseous fuels, with which alone we can expect to be able to obtain a complete mastery over the baking.

Having reviewed as succinctly as possible the principal points in the fabrication of porcelain, we now come to the description of the processes employed to enrich that beautiful material. The art of fixing colors on pottery differs essentially from that of fixing them on cloths, wood, and paper; besides, special qualities, distinguishing it from all other kinds, are exacted of ceramic decoration. A perfect adherence, an absolute resistance to atmospheric agents, a glaze that shall permit the colors to be confounded with that of the object itself, are the characteristic qualities of a handsome ceramic decoration. Since the glazing of porcelain is a rock, one of the hardest substances of the mineral kingdom, it is easily understood that absolutely special processes must be adopted to make a color adhere. The result can be reached only through the intervention of an elevated temperature; and this fact eliminates at once from the palette of the ceramist all organic coloring matters and all minerals of slight stability. We must have recourse to oxides, metallic silicates, and metals. The fixation of these colors is always the result of a chemical action, of a combination that takes place at a high temperature, between the body or the glazing of the porcelain and the materials employed to decorate it. Several different methods are applied for this purpose, but they may be

divided into two classes: decoration by the sharp-fire, and decoration by the enameling furnace. The former method consists in the application upon the porcelain of coloring substances which are fixed and developed upon it at the same temperature as that at which the porcelain is baked. It is the method that gives the most highly prized results, for with it the color is covered by the enamel, and takes a high luster and deep setting, becoming, as it were, of one body with the object. The magnificent blue of Sèvres, certain browns, the blacks, and a few other shades are obtained by this process.

The color may be mixed in the paste, or put on the fashioned object, before enameling, or mixed with the glazing; or it can be put upon porcelain that has been baked and will then be baked a second time in the sharp-fire. This is the process we employ at Sèvres for our blues.

One of the most brilliant varieties of decoration by the sharp-fire consists in what is called the process of applied pastes, or in painting with barbotine upon the raw or biscuit-baked porcelain; by successive, rightly tempered applications we can lay on a considerable thickness of material, on which the artist can with the chisel give a fine finish and thus add great value to his decoration. When the barbotine is applied upon a tinted bottom, charming effects, making the porcelain look like real cameos, can be obtained in the clear material. If coloring oxides are added to the barbotine, a real picture can be obtained. Unfortunately, the number of colors that can be used in the sharp-fire is, on account of the excessive temperature, very limited.

In decoration in the enameling-furnace, the painting is always done on baked porcelain, consequently on enamel, and the heating takes place at a relatively low temperature. Since the glazing is not to be melted, as in the sharp-fire, an intermediate agent or flux is required to make the colors adhere. This is generally a silicate or a silico-borate of lead, or for metals a sub-nitrate of bismuth. When the temperature is raised, these substances melt, attack the glaze, and combine with it, determining by their reaction the adherence of the color. The temperature in these operations is determined by the nature of the fluxes and of the colors; and, as some colors are more sensitive than others, it is frequently necessary to bake in two successive and different fires.

The palette of Sèvres is complete, and is competent to reproduce with a marvelous excellence the chief works of the greatest painters. Notwithstanding the beauty of the sharp-fire colors, and the richness of the palette, much is still left to be desired in the decoration of French hard porcelain. The sharp-fire colors are too limited in number and too delicate to admit of any great variety of effects being drawn from them; and the colors of the enameling furnace, in spite of their richness, have a capital fault. They are opaque, and they cover the porcelain and hide all of its highly prized qualities.

Improved processes of decoration have been devised by M. Salvetat and M. Ebelmen, of which the manufactory of Sèvres has possession, and which, I believe, will permit the substitution for painting of a lively and brilliant decoration, as distinct as that of delf, but which will be as superior to that as the material to which it is applied is more precious and delicate. Using these processes, the artists of Sèvres will be able to go beyond making commonplace copies of what has been made in the East, and to create a genuine French school of porcelain, restoring that material to the high rank which the artistic delfs have nearly taken away from it.

I consider that the manufactory at Sèvres, being a national establishment, supported by the country, ought to lay aside the character of a factory, and become a school of ceramics, devoting itself to the search for new processes, for original forms and decorations, to the creation of workmen and artists who shall be masters in their business; and that it is its absolute duty to give to French industry the results of its investigations. Thus might it become a most useful element in the national industries, and a glory to France and the republic.

THE PHYSIOLOGY OF EXERCISE.*

BY EMILE DU BOIS-REYMOND.

I.

ALTHOUGH the reputation of the Romans as a civilized people has somewhat sunken of late, their army-life still awakens unbounded admiration. The Greeks called their army after the camp, the Macedonians after its formation. To the neo-Latins the army is armed power; the Germans seem to regard it as a union of the warriors into a common host. The Romans, on the other hand, as Gibbon has remarked, named their army from exercise. The Greeks aimed at the harmonious development of individuals, without any well-defined purpose. Incessant methodical drill of the manhood, a field of Mars, is essentially a Roman institution, for war was the natural condition of the Roman commonwealth.

Overthrown by the barbarian hosts, the regular army disappeared from the world's stage for a thousand years, and the greatest question of controversy for mankind, whether Christian or of Islam, was how once upon a time the quarrel of a clan over a pretty woman was decided by single combat of knights before Ilium. With the revival of ancient culture on the threshold of the new time, the drilling of troops came again into its right. No one now doubts that, other things being

* An address at the anniversary of the Institute for Military Surgeons, Berlin, August 2, 1881.

equal, the better-schooled army prevails. Hardly any army deserves better than the Prussian-German the name *Exercitus.* Before a meeting of the physicians of that army it is not inappropriate to consider exercise somewhat in its direct physiological aspect.

Boyish excesses have brought the Darwinian doctrine into such bad repute in wide circles that I do not without consideration place myself at its point of view. Yet, whatever view of the world one may take, science, which desires to comprehend the world, will not be prevented from at once representing the world comprehensively; since it, according to Herr Helmholtz's evident remark, must start out from this presupposition unless it is contradicted at the outset. Only mechanical conception is science; when supernaturalism comes in, science ceases. As the jurist takes the law, without considering equity and palliating circumstances, so the naturalist goes on to mechanical conclusions, without regarding venerable beliefs. It is not his office to reconcile these beliefs with those conclusions.

More, the Cuvierian doctrine of repeated creations underlaid by repeated cataclysms has lost all justification since Lyell showed that goeological phenomena have proceeded without general cataclysms, and Darwin has added that species change. Now we can more intelligibly ascribe to the creating Almighty only the action of having placed a first germ of life in previously inanimate nature. Is it not, then, simpler and more worthy of that Almighty to conceive that he at once endowed matter with the power of allowing the living to arise out of itself under definite conditions, without new assistance?

This was Leibnitz's view, and it may be said of it that even the most cautious need not be afraid of it. According to this view, it is the object of natural research to show how the living originated by mechanical processes out of the inorganic, and how, out of this doubtless most simple life, the present organic nature has been mechanically developed. If we could succeed in filling up the scheme of the theory of descent with real contents, we should know how the series of living beings has unfolded itself during unlimited time and through numerous generations, according to certain norms which appear to us as laws of organization. But with this the problem would be only half solved.

Living beings are in themselves fitted to their purpose, and adapted to the external conditions of their lives; they were always so; and, while they transform themselves according to their surroundings, they not merely adapt themselves to their new conditions, but they also perfect themselves in our human conception. Thus, from this point of view, organic nature appears not only as a machine, but also as a self-improving machine.

This second half of the problem demands for its solution the proof that the adaptive process has gone on mechanically, and the only not wholly vague effort to give this proof that has yet been made is the

theory of selection. Unfortunately, however, this theory encounters insuperable difficulties as soon as it tries to step from the free-sailing air-balloon of probabilities upon the hard ground of realities. Nothing is easier than to ridicule the doctrine of natural and sexual selection. So much the more earnestly will the seeker for truth seize any means that can contribute anything to the solution of the problem. Is it not now a most promising coincidence that the higher beings exhibit in exercise such a self-improving machinery as we have recognized in the aggregate of life?

From these remote distances of research, which are the peculiar metaphysics of our time, come with me into a blacksmith's shop. The lad who lifts the hammer for the first time to-day soon becomes tired in spite of his splendid muscular foundation. He sweats; and, when he takes a horseshoe from the master's hands, he burns his fingers. Two years later he can, without sweating, perform the trick illustrating the mechanical theory of heat of pounding cold iron red-hot, and is not afraid to touch the hot metal. What has happened? First, the lad's arms have increased in compass, their muscles in tension to the highest capacity of contraction. If we could have weighed the muscles of his arms at the beginning of his apprenticeship, and could weigh them now, we should find that they had grown heavier; as also, according to Edward Weber, the muscles of the right side of the body are heavier than those of the left. The muscles are also the most perfect power-machines—not only in that when active they make the most complete use of the consumed matter; not only in that, according to Herr Heidenhain, their strength in particular instances increases with the service demanded of them—but they are distinguished above all machines made by man in that by frequent labor-service they become stronger and more capable of enduring further labor. It does not need to be proved that the effect of exercise on the muscles is immediate and local, and not transmitted through the favorable influence of bodily exertion on the general organism. Even the Greeks found fault with the disproportionate degree to which boxers trained their arms only, and runners their legs; and our pugilists and ballet-dancers are illustrations of the same. Under some circumstances the local results of exercise may be destructive to the whole, as when the muscles of the heart suffer hypertrophy in consequence of excessive resistance in some part of the circulation.

On the other hand, the surgeon knows only too well that the muscles of a stiffened or sprained joint, or of one that has been confined with bandages, become wasted, as do likewise muscles the nerves of which have been cut or that have been otherwise disabled.

The part is known which the latter fact, falsely interpreted by the older physiologists, played in the question of what was called the Hallerian muscular irritability, till John Reid—at a time when experiments on living animals were not prohibited in England—showed

that muscles deprived of their natural innervation could be kept fit for work provided they were electrically excited at sufficiently brief intervals; an experiment which found an important application in surgery and neuropathology.

Even in the midst of health unused muscles pine away, or become pale and powerless, like the ear-muscles of most men. In general, the redness of muscles is related to greater strength in consequence of frequent exertions. Herr Ranvier showed that the red and pale muscles occurred together in rabbits and rooks; that they were distinguished by their structure and by the time required for contraction without its being possible to decide that one set worked more than the other, and without any clew being given to the object of this disposition. Little is known of the microscopic qualities of used and unused muscles. In contrast with the muscles of fattening cattle, working cattle have thicker primitive bundles and coarser sarcolemma, the latter determining the lesser nutritive value of the flesh. According to Herr Virchow's terminology, nutritive stimulation has also taken place. In muscles falling away through disuse, as the waste progresses a fatty metamorphosis sets in, against which, as is well known, its ceaseless activity does not protect the heart-muscle. Muscular contraction is accompanied by chemical changes. The blood flows darker from tense than from resting muscles; they consume more oxygen and form more carbonic acid. An acid permanently reddening litmus is set free in them. Their watery constituents and the amount of substances soluble in alcohol increase in them, while the amount of substances soluble in water diminishes—probably because glycogen is consumed in the contraction. The albuminous constituents remain about the same, yet the derivatives of albumen known as the flesh bases appear to be richer. That to the last hard-working muscle, the heart, is for this reason a mine of such bodies to the chemist; and the flesh of a fox that had been shot was found by Liebig to be ten times richer in creatine than that of a captive fox. We are, unfortunately, still very far from understanding the connection of these various processes and their relation to muscular contraction, that is, to the interchange of isotropic and unisotropic substances in the muscular fibers, and to the transformation of mechanical, thermic, and electric forces. We only know that there is involved an increase and modification of a process of change that was already going on during rest, particularly of the oxidation of nitrogenous substances, by which, in addition to mechanical labor-service, an apparent surplus of heat is developed. Even the muscles at rest are a seat of respiration and the development of heat in animal bodies. The muscle acts very much like the reserve-locomotive that stands ready for use on the switch, which is all the time burning a little fuel and can be attached to a train or sent to help a disabled engine at any instant, but which requires, in connection with the greater display of force it is to make, a greater consumption of material and expenditure

of heat. Ludwig and Sadler showed on this point that, aside from mechanical hindrances, the blood flows freer and richer through the vessels of the working muscle. This is not only in the sense that new combustible matter is introduced, but also in that the ashes are at the same time swept away from the muscle-hearth; since, according to the discovery of Herr Johann Ranke, followed out by Hermann Roeber, the acids formed by muscular activity depreciate the mechanical and electrical capacity of the muscle, exhaust it chemically as we are accustomed to say, without being able to conceive any other than a chemical exhaustion of the muscle. Still less than of the chemical mechanism of muscular contraction, have we a conception of what takes place chemically in the strengthening of the muscle by exercise, of how it becomes better fitted for work through a higher degree of oxidation, and of why it falls away on the cessation of the changes that take place in it in activity. It seems most natural to think that these effects depend alone upon the increase and diminution of the flow of blood during activity and during rest; yet this of itself only makes the case darker than if we had not ventured to decide the question in such a way. Chemistry throws the manifold varieties of muscle-flesh which our taste distinguishes with so much refinement generally into one pot; and the old statement, established in knowledge, that English park-deer tastes flat, is still far from being explained.

A subjective explanation is finally to be mentioned. The tired muscle, as long as it is becoming stronger through exercise, gives pain for several days when it is used and when it is pressed upon. Even a muscle which has been once or oftener hardened, or thoroughly trained, gives pain when it is again put to work after a long idleness, as we soon learn when we begin a journey on foot or on horseback. Whoever, after a long interruption in gymnastic exercises, feels no more pain, will make no further progress. The muscles hurt after epileptic spasms. Even if we attempt to ascribe the feeling of the muscles to the nerves of the tendons, joints, and skin, and the Vater-Pacini bodies, we still should not imagine that they bring on the pains in tetanus and trichinosis. Notwithstanding Sach's labors, we are not yet in the light concerning the pathic nerves that bring about these pains. Wherever and however they do it, they also produce muscular aches after exertions.

The improvement of the muscles by exercise, little as we know of it, has been established from antiquity, and, being relatively more familiar, the best case of improvement, is fitted to serve as an example for similar processes in other tissues. Indeed, the question now is, whether other tissues than the cross-striped muscles are by frequent exercise of their office in the animal household made better fitted for that office. After what has been said above, we can with some justification add to this question the many times more

easily answered one, whether other tissues diminish in consequence of a failure to exercise them in their office.

A physiological proof that the smooth muscles are strengthened by exercise is wanting. The adaptation of the eye to near vision diminishes from childhood to age according to a regular law, notwithstanding the constant exercise of the faculty; but it does not follow from this that Brücke's muscle does not gain strength, for its gain may be more than compensated by the growing stiffness of the tissue and the diminished elasticity of the crystalline lens. The fact that men see imperfectly at close range what their occupation gives them little occasion to regard, indicates that Brücke's muscle loses strength when it is not used. The uterus has no occasion to be exercised, for it is active only after long pauses, and gains a portion of new fibers every time for that purpose. We know nothing of the movements of the muscle-maw of the bird, which forms a transition to the cross-striped muscles. On the other hand, such pathological facts as the hypertrophy of the muscles of the bladder and the pylorus under circumstances of extraordinary resistance leave no doubt that the smooth muscles, like the cross-striped ones, are strengthened by labor. Thus an empirical basis is given to Herr Rosenthal's supposition that the immunity against cold conferred by cold-bathing depends upon the exercise of the smooth muscles of the skin and their vessels, which are intrusted with the lowering of the co-efficient of cooling of the body in the cold. Cold washing and bathing are the gymnastics of the smooth muscles.

The young blacksmith, of whom we spoke a short time ago, had gained another advantage from exercise besides greater strength in the muscles of his arm: he ceased to burn his fingers. Every one knows that the epidermis thickens on those parts of the skin that are frequently subjected to pressure, rubbing, and the touching of hot things and caustic fluids. Handling of tools, rowing, vaulting on the rack and bars, produce a callus chiefly at the ends of the middle-hand bones or in the palms; glass-blowing produces callus on the inside of the fingers. Recurrent blisters often result in callus. Under the pressure of hard shoes the form of skin-thickening known as corns takes the place of callus. Callus and corns have been histologically investigated, yet we can not tell why the useful callus is formed here, the painful corn there, to say nothing of our having a theory of the processes. They fall in the category of what Herr Virchow calls formative stimulation of the cell-complex, and regards, like the nutritive stimulation, as the result of a general and fundamental property of the elementary organisms. An increased supply of matter, immediately conditioned on an increased flow of blood, also takes place here. Since we can not well predicate a *vis a fronte*, enlargement of the vessels remains the only yet possible step toward an understanding, and with this we reach a closed gate before which many other problems are

already encamped, in the question how inflammation and vascular paralysis are distinguished. Our case is also distinguished by the fact that the skin, protected by callus like the practiced muscles, now affords better service under similar circumstances. The callus, in particular cases, represents an improvement in the grasping organ. Formative stimulation also occurs in the muscles; the contents of the primitive bundle are moved to nucleation through local stimulation, yet the advantageous stimulation by exercise seems to be almost entirely, or chiefly, of a nutritive sort.

In like manner as the skin fortifies itself against the repeated touch of hot bodies by means of local calluses, it adapts itself to the heat of the sun through erythema and a change consequent upon it which is accompanied with the development of pigment, although pigment favors the absorption of the sunbeams. The fact is, perhaps, connected with this, that it is advantageous to animals to have the side that is turned toward the light of a dark color. Hence, as Moseley observed on the Challenger, *Echeneis remora* has the belly dark, the back light. Heat from artificial sources of a relatively lower temperature, which is deficient in refrangible rays, has a remarkably different effect from sunlight. Workers by the fire are pale. It is still to be seen whether the electric light will take the place of the sunlight in its effect on the skin as it does in the case of plants.

Horny structure becomes unfit for its purpose with insufficient use. A remarkable example of this is the cessation of the growth of the hoofs of horses and cattle on the soft turfs of the Falkland Islands, mentioned by Darwin. On the other hand, the hoofs of horses harden on dry, stony soils, as Xenophon teaches in his school for horsemen; and colts brought up on such soils need no protection.

The so-called rider's bones, the exercise-bones, which have not become rarer since the introduction of the new armor and the modified drill, but have moved from the left to the right, may be considered as a kind of inner callus, the development of which affords a new exemplification of the Osteo-blasten theory. These bones hardly bring any advantage to their possessor, and can not be included among the instances of self-improvement through exercise. It would be too far fetched and groping in a too dark quarter for me to do more than mention here that Ludwig Fick believes that the well-adapted form of the joints may have been derived from exercises during the fetal period and the earliest days of life. Is it not possible that the splendid formation of the spongy bone-substance in the epiphyses, which was discovered by Hermann Meyer, and further investigated by Julius Wolff, depends on nutritive and formative stimulus in the direction of the greatest pressure and strain? The injurious effect of insufficient use is shown in this region by the non-growth of the teeth of rodents when they are fed on too soft food, or after the trigeminus has been cut.

The self-improvement of the series of connecting tissues by exercise in other members, takes place in a more peculiar manner, rather mechanical than chemical and physiological. The motions of the joints are made easier by exercise; and making stiff joints movable is one of the most grateful objects of orthopedy. Herr Henke explains the unusual suppleness of the so-called India-rubber men as the result of relaxation of the ligaments, a disappearance of edge-surfaces of bone, and a diminished radius of curvature of the sliding surfaces, but particularly of a prolongation of the flesh-fibers at the expense of the tendons. Possibly an elastic tissue is formed in the ligaments of their limbs. Whether such a tissue grows in the vocal cords after exercise in vibrating them is still uncertain.

To make our statement complete, the increased ease in labor—bought, it is true, at the cost of greater danger of secondary bleedings—of those who have borne many times, belongs here. We may also regard as a self-improvement, although belonging to another region, the relaxing after-birth, and the accompanying reflex action of the breast upon the uterus.

The glands are another class of tissues the efficiency of which is raised by exercise. The sexual glands—the milk-glands and testicles—are known to be capable of remaining at rest for years and even for life, while their tissues are subject to a considerable diminution, as is also normally the case with animals during the intervals between the periods of heat. Inversely the sexual glands attain a wonderful degree of production by means of alternations of rest and activity, as is exemplified by stallions, milch-cows, sheep, and goats. If the breast-glands are not kept exercised by sucking, the udder by milking, they dry up and sink to rest till they are newly excited in sympathetic action with the uterus. The same can not be immediately proved of the fluids of secretory glands, but it is hardly doubtful that a digestive vessel that is kept active by two meals a day, with its glandular attachments, will dispose of a larger quantity of the various digestive fluids than that of a penitent. The kidneys of the practiced beer-drinker give passage to an incredible quantity of fluid. Finally, one who reads in the sketches of the manners of the last century of the continual weeping of the sentimental men and women of the time, will hardly be able to restrain the presumption that their tear-glands were brought up to the work by practice. We are as ignorant concerning the mechanism of the self-improvement of the glands through exercise as concerning the process of secretion in them. Since this process is different in nearly every gland, according to what nerves are introduced—in one the secreted matter increases; in another becomes fatty; in another persists unchanged, but receives and gives out matter, or undergoes changes in itself—the problem appears twice as intricate and the information doubly scanty, so that at last we have to do again only with an increased accession of matter and more frequent innervation.

The idea of exercise as we have regarded it passes so gradually over to hardening against frequently repeated injuries, that I am tempted to place here also the adaptation of the organism to accustom itself to endure poisons. Without going back as far as King Mithridates, many men have by habit made themselves comparatively proof against alcohol, nicotine, and the alkaloids of opium. The North-Germans are only too proof against Pettenkofer's man-poison (my anthropotoxine) in badly ventilated assembly-halls, railway-carriages, etc., to which fire-place people, like the English, are so sensitive. This inurement can hardly be called self-improvement.

You have, perhaps, gentlemen, been waiting in impatient expectancy for me to speak on the subject you first thought of when you heard that my address was to be on exercise. By exercise we understand commonly the frequent repetition of a more or less complicated action of the body with the co-operation of the mind, or of an action of the mind alone, for the purpose of being able to perform it better. Not without a purpose have I deferred the consideration of this kind of exercise to this point, for it is quite different from the kinds previously spoken of, although those kinds may be connected with it. This fundamental difference has not as yet been duly considered. We seek in vain in most physiological text-books for instruction respecting exercise; if it is given, only the so-called bodily exercises are generally considered, and they are represented as merely exercises of the muscular system; therefore it is not strange that laymen in medicine, professors of gymnastics, and school-teachers generally believe that. Yet it is easy to show the error of this view, and demonstrate that such bodily exercises as gymnastics, fencing, swimming, riding, dancing, and skating are much more exercises of the central nervous system, of the brain and spinal marrow. It is true that those movements involve a certain degree of muscular power; but we can conceive of a man with muscles like those of the Farnesian Hercules, who would yet be incompetent to stand or walk, to say nothing of his executing more complicated movements. For that we have only to add to our conception the power of arranging the motions suitably, and of causing them to work harmoniously.

Thus it becomes clear, if proof were needed, that every action of our body as a motive apparatus depends not less, but more, upon the proper co-operation of the muscles than upon the force of their contraction. In order to execute a composite motion, like a leap, the muscles must begin to work in the proper order, and the energy of each one of them (in Helmholtz's sense) must increase, halt, and diminish according to a certain law, so that the result shall be the proper position of the limbs, and the proper velocity of the center of gravity in the proper direction. We know little as yet of the way in which we impart a definite duration to the energy of the muscles, for our researches have so far informed us upon little else than the convulsions following extremely

brief excitations, and upon tetanus. Since the nerves only transmit the impulses coming from the motor-ganglion cells, it is evident that the peculiar mechanism of the composite movements resides in the central nerve-system, and that, consequently, exercise in such movements is really nothing else than exercise of the central nerve-system. This possesses the invaluable property that the series of movements (if we may speak thus), which take place in it frequently after a definite law, are readily repeated in the same order, with the same swell and ebb and intricacy, whenever a singly felt impulse of the will demands it. Thus, all the bodily exercises we have mentioned above are not mere muscle-gymnastics, but also, and that pre-eminently, nerve-gymnastics, if for brevity we may apply the term nerves to the whole nervous system. Johann Müller, whose explanations, in the second volume of his "Hand-book of Physiology," still appear to me the best that have been written on the theory of movement, has recognized this double nature of bodily exercises, but has not sufficiently insisted upon it. On this, he makes a remark which strikingly enforces our view; that is, that improvement in exercises of the body often consists nearly as much in the suppression of unessential by-motions as in acquiring dexterity in necessary motions. Observe the active boy who for the first time raises himself upon a ladder with his hands. Although it is of no use to him, his arms and his legs shake at every grasp. After a few weeks he holds the hips, knee and foot joints of his closely locked legs tautly extended. The suppression of by-motions furnishes unconsciously to us a mark of the pleasing appearance of the well-drilled soldier, of the skilled gymnast, and of the cultivated man; chorea begins when they are let loose. We know nothing of the mechanism of the suppression of by-motions, yet it is evident that, when muscles remain at rest in the course of exercise, the result of the exercise is not to strengthen them.

Under continuous severe exertions, as in mountain-climbing and long walks, the heart begins to beat faster and more strongly, and oppression of the breath is felt, because, according to Johann Müller, the heart participates in a by-motion; in Traube's opinion, because it is stimulated by the excess of carbonic acid formed in the laboring muscles. How is it, then, that exercise diminishes these palpitations? Is it by means of the vagus nerve?

Perspiration under exertion may also be regarded as a by-secretion as well as the greater secretion of saliva in speaking and chewing; and the diminished perspiration of our blacksmith when taught would then be the suppression of this by-secretion, which might be compared to a by-movement, through exercise. The beating of the heart and perspiration are, however, involuntary, and it is very questionable whether we can refer the stopping of them by means of exercise to such processes.

Still, something else than the control of the muscles by the motor-

nervous system comes into consideration in most composite movements. The sight, the sense of pressure, and the muscular sense, and finally the mind, must be prepared to take in the position of the body at each instant, so that the muscles may be in a proper state of adjustment; this is plainly shown in the exercises of fencing, playing billiards, rope-dancing, vaulting on horses in motion, or leaping down a mountain-slope. Thus not only the motor, but the sensor nervous system also, and the mental functions, are capable of being exercised and need it; and the muscles again appear to acquire a deeper importance in gymnastics. What is said here of the coarser bodily movements applies equally to all skilled work, of the highest as well as of the lowest kind. Although a Liszt, or a Rubinstein, without an iron muscularity of arm, can not be thought of, and although, likewise, the movements of Joachim's bow during a symphony may correspond to many kilogrammemetres, still their power as virtuosos resides in their central nerve-system. The readiness of the turner, the machinist, the watchmaker; of the glass-blower and glass-polisher; the skill of the anatomist and surgeon; writing and drawing; womanly labors like sewing and knitting, crocheting and lace-making; finally, the hardly considered yet more or less artful performances of daily life, dressing and undressing, the use of the sponge, comb and brush, knife and fork—what are they all at last but acquired concatenations of the actions of ganglion-cells which, after they have often run on in an appointed course, now succeed each other in the same manner with qualified facility, catching into each other, pausing and resuming again, like the voices in an artfully composed concert? When Lessing asked whether Raphael would have been any the less a great painter if he had been born without hands, he perceived this truth. Is it necessary to add that the same principle applies to all the movements as well as to those of the hands; that, for example, vocal culture rests upon no other one? Singers need not only flexible vocal cords, strong respiratory and laryngeal muscles, ringing resonance of the air-passages—all these would in themselves alone be of no more use to them than a Stradivarius violin to a wood-cutter—their talent has its root in the gray substance at the base of the fourth ventricle. Here also is concealed, but awaiting a higher command, exercising its functions through the hinder third of the left third convolution, the machinery of the speech mechanism, as bulbar paralysis sadly teaches.

It is very remarkable in all these processes that the more any composite movement is practiced, the more unconscious is the act of the nervous system directing it, until at last the latter can not be distinguished from spontaneous nervous mechanisms like the involuntary reflex and by-movements. Erasmus Darwin remarked that, when any one learns to turn, each movement of the hands seems at first to be directed by the will, but that at last the action of the hands becomes so at one with the effect that the turner's will seems to reside in the

cutting of his knife—that is, that he unconsciously puts it in the right position.

Practice further exhibits its influence upon the nervous system on its purely sensory side, abstracted from all movement. It sharpens and corrects the musical ear, and teaches it to perceive over-tones, inexact intervals, and slight dissonances. The local sense and the color sense of the eye are improved by practice. It teaches the wonderful arts of quick reading, of taking in fleeting phenomena like the vibrations of the magnetic needle, of bringing the sight of the gun to bear on the black of the target. It teaches to distinguish copies and all kinds of subjective appearances, to comprehend at a glance microscopic pictures that pass before the beginner in superficial confusion, in such a way that it is very hard to draw the line between exercise of the sense and that exercise of the judgment over the impressions of sense that is called *visus eruditus*. As exercise induces the discontinuance of unused muscles, it also teaches us to neglect unused images, such as the double images of the points of the picture outside of the horopter; or, in looking through an optical instrument, the impressions made upon the unengaged eye. Yet no practice appears to break through the law according to which the points of the retina in indirect vision receive attention only transiently and with a certain effect. Although it is hardened against bad smells, the nose of the chemist is the rival of spectrum analysis in delicacy. It would be unjust to say that the wine-connoisseurs of Bordeaux can discriminate concerning the place of the growth of a vintage, while only its age is in question with them. Not less susceptible of cultivation are the perceptions of temperature, pressure, and locality. The last, especially, measured according to the least distance at which two bodies, nearly in contact, still separate, may be distinguished, become sharpened by practice in the course of a few days—giving one of the arguments which oppose a purely anatomical definition of the range of feeling.

As exercise refines the senses, neglect stupefies them, and that not merely in consequence of the apathy of the organ. After destroying the eyes and ears of new-born puppies, Herr Hermann Munk observed that what he had recognized as the visory and auditory spheres of the brain borders were backward in development. According to Huguenin, blindness of many years' duration results in waste of the visory spheres.

A CURIOUS BURMESE TRIBE.

By Lieutenant G. KREITLER,

OF COUNT SZECHENYI'S CENTRAL ASIAN EXPEDITION.

In our journey from Sayang in Yunnan to Bhamo in Burmah, we became acquainted with a race of mountaineers who are called Kacheen by the Burmese, but who call themselves Chingpos. They

are a small, delicate people, whose brightly-beaming eyes contrast strongly with their reserved behavior. The faces of the men as well as of the women can not be called unhandsome. The head is oval and well-shaped, the eyes are horizontal, the nose is strong and straight, the ruddy lips are finely cut, and the teeth are blackened with betel-juice.

All the hard work among the Kacheen is done by the women and girls, who are up in the morning at their household duties while the men are still in bed.

The woman does not venture to raise her eyes when she speaks with her husband or her employer. She has no concern about the business or enterprises that he is engaged in, but considers everything good and unquestionable that he orders ; and the subjection of the women goes to the extent that the death of one is lamented as a pecuniary loss, because the laboring force is diminished by it ; and a family that has several daughters is for that reason considered rich. The women are all the time at work, cutting down trees, splitting wood and bringing it to the house, cutting roads through the thickets, driving the cattle to pasture, cleaning the house, getting the meals, and weaving cloth. The men perform no manual labor, or, at most, will once in a while go out into the field and show the women in a rough way how the tillage ought to be done. Their principal business is to visit their neighbors, to drink *sheru* (a sweet drink made from rice), and smoke opium. Only in case of pressing need will they take their mules and their women and go to Bhamo and get loads of goods to take to China. Marriages among the lower classes are mere business affairs, in which the dowry and physical strength of the bride are the first considerations. Among the higher classes weddings are regarded as important events, and are distinguished by particular usages and ceremonies.

When a death occurs, the relatives make the sad event known to their neighbors by firing guns. When the friends are gathered together, a part of the number go into the woods to prepare the coffin, while the others sacrifice to the household gods. The coffin is hewed out, after sacrificing a hen, at the place where the tree is cut, and the part where the head is to lie is blackened with coal. The corpse is washed, dressed in new clothes and laid in the coffin, with a piece of silver in its mouth to pay its ferriage over the river. The old clothes of the deceased are laid, with a dish of rice, upon the grave, and rice is scattered along the road on the way home. The mourners afterward assemble and celebrate the event with singing, dancing, and drinking, as long as the *sheru* lasts.

Persons who die by the sword are wrapped in a straw mat and buried as soon as possible, and the friends build a hut for the wandering spirit of the slain. A similar custom prevails with regard to those who die of small-pox, and to women who die in childbirth. In the

latter case, the Kacheen believe that the dead are changed into evil spirits, and for that reason young women have an indescribable horror of such a death.

It is evident from these facts that the religion of the Kacheen has nothing in common with Buddhism. Their religion includes the belief in a Supreme Being who has created everything, in a heaven and a hell, and a future state of rewards and punishments; but the views of individuals do not give the slightest clew to a clear definition of their faith. The mountaineers, however, all agree in a *cultus*, which consists in giving honors to the so-called Nats, or tutelary genii. They also believe that the spirits of murdered persons, under the name of Munda, make the mountains unsafe, and that they take possession of those persons over whom a similar fate is pending. The Kacheen have an unwritten language, and a very primitive method of computing time. Their year begins on the day when they begin to eat the newly harvested rice, and ends on the day that a dish of fresh rice is again gathered.

Slavery has existed among them from a considerable antiquity. Boys and girls are stolen in Assam and sold to wealthy Kacheenese. A young slave is worth about twenty dollars, a full-grown man only about ten dollars. The lot of the slaves is not very hard, and their children are regarded as more or less members of the family.

The food of the people consists of rice, beans, pork, and dried fish imported from Burmah. The men eat separately from the women.

Their towns are composed of from three to ten houses, each of which is surrounded by a stone-wall about six feet high. We were always required to dismount before passing the wall, for the mountaineers have religious scruples against allowing persons to ride on horseback into their courts. The houses are light bamboo structures, without iron or stone work. A north-and-south passage leads into the interior, which strangers are allowed to enter only from the south. First we passed a stable, whose fence was adorned with the horned skulls of buffaloes, and the marshy floor of which yielded at every step. A few steps led to the dwelling-house proper, which appeared to be divided into a western and an eastern half. The western part consisted of a series of closed rooms, the eastern half of three apartments open toward the long passage, in the middle and largest of which was built the hearth, where a fire was constantly kept up.

The head of the house and his family live in the inclosed rooms, the domestics and slaves in the opposite rooms. The floors are of plank, and kept clean, and the ceiling is identical with the smoke-blackened roof. The whole house is built on piles. The few other domestic buildings are grouped around the inclosure-walls, and are commonly situated on the edge of the thick and gloomy forest.

The Kacheen call all their chiefs, who rule each over a small territory, Tsobwa. The Tsobwa receives yearly from his subjects as tithes

a large basket of rice and a quarter of the meat whenever a domestic animal is slaughtered; and he exacts a small toll from every caravan that passes through his domain. His office is hereditary, as is also that of his prime minister, who is called Pomein. The chief himself administers justice; but in important cases he calls a council, which meets either around the fire in the house or in the open air. These chiefs seem to be quite independent, and only indirectly under the influence of the Chinese Government. The relations between the Kacheen and the Burmese are of constant hostility, frequently breaking out in murderous outrages. The country of this people is a broad strip of land extending from the Snowy Mountains of the north, between the valleys of the Tapeng and the Irrawaddy, to about the twenty-fourth parallel of latitude.

PROBLEMS OF PROPERTY.

By GEORGE ILES.

THE problems of property form an interesting department of social science. They involve questions as to the growth and distribution of wealth, the province of government with respect thereto, and similar inquiries scarcely susceptible of treatment by formal scientific methods. Still, the subject is one of sufficient importance to warrant a brief sketch of it appearing in the magazine which was the first to give the American public a scientific exposition of the principles of sociology.

The institution of property is, in many quarters of the world, finding active criticism. German and French socialism, Russian nihilism, the Irish Land League, and weighty utterances by the leaders of thought in Europe and America, all declare that the institution of property requires reconsideration and reform. It is very commonplace, indeed, to say that respect for the rights of property insures the chief stimulus to industry, intelligence, and thrift; yet, in the complexity of modern life, the distribution of wealth has become so unequal that discussion of how justice may be feasibly and safely introduced into the laws and customs affecting property is of urgent importance. The natural differences among men in the way of aptitude and ability are always wide enough to cause a variety in human fortunes sufficiently trying to the less capable classes of mankind, were there at work no other cause for disparity in worldly success. When, however, in addition to having to accept the smaller reward in the smaller sphere, the man of but moderate or little ability has to suffer the restrictions which come from the artificial enactments of law and society, discontent easily takes root in his heart and flourishes.

The spur to the accumulation of wealth is undoubtedly sharpened by the power of bequeathing one's possessions to one's family and friends; yet it is this power of bequest, gradually increased through the centuries to its present breadth, which furnishes the most difficult part of the problem of property. Re-enforced in Great Britain by the laws of entail and primogeniture, it has led to the concentration in the hands of a few of a large proportion of the entire wealth of the country. The heirs of unearned lands, houses, and funds are without the healthy natural spur to useful work which universal experience declares necessity to furnish; and subtile moral poison is distributed through society when, as in Great Britain, long trains of bequest bestow the choicest estates and social positions in the realm upon a few individuals through the mere accident of birth. When merit and the means of enjoyment are so often unrelated, as we see them in Great Britain, there is valid ground for complaint and a plain source of envy on the part of the millions apportioned to toil, while some have unearned luxury and ease. Is it right that, because a man, centuries ago, was successful in battle or a favorite of his king, or generations ago was engaged in lucrative trade and thus gathered possessions together, his posterity should be maintained for indefinite time by the working world? And is it right that his descendants should reap richer and richer rewards, as years roll by, from the increase in value conferred upon their estates as the surrounding population grows more numerous and advances in intelligence and industry? Why should books and inventions, which are peculiarly the creations of a man, be so imperfectly protected, and only confer rights terminable in a few years, when rights in ordinary property are so nearly absolute? Such are the questions which are being put to the political economists and legislators of to-day, and their just and peaceful solution will demand a wisdom and forbearance which we may be disappointed in expecting.

The most patent evils with which the institution of property is commonly charged are those connected with land, and here it is that the agitation for property reform has usually begun. The researches of Sir Henry Maine and M. Laveleye show that the primitive cultivation of land was communal. Such still is the Russian *mir* and Swiss *Allmend*. Under communal systems every child born upon the land was guaranteed subsistence, and wide disparity in fortune between individual and individual was scarcely possible, so that pauperism was unknown. How the communal systems gave birth to our existing methods of individual possession M. Laveleye tells in an interesting way in his work on "Primitive Property." The practical fact which concerns us is that, among civilized nations individual property is established and is held to need reform. The change from communal and clan ownership of land to the tenure of recent times has been attended by a gradual divorce of the responsibility which formerly attached to land-owning; if the responsibility now exists at all,

it does so as a moral feeling which may be neglected with no legal penalty and often no social odium. The Duchess of Sutherland could banish the occupants from the estates which their ancestors had tilled for centuries, and convert the land into pastures, yet legal resource there was none. A sybarite Marquis of Hertford could live in Paris for thirty years together, with an income of ninety thousand pounds, and dismiss without a reply a deputation of his Irish tenants petitioning for assistance in building a much-needed railway. Could the original founders of the two families thus unworthily represented have treated their retainers and tenantry thus haughtily and unjustly, and not suffer for it? I think not. The rules of property, devised with a limited glance into future time, and with no expectation of the vast strides in population and wealth which the world has made during the past century, have had very awkward strains put upon them—strains which they were not originally expected or intended to bear. The rise of manufacturing towns and the drift of the rural population to the cities have conferred upon land-owners an immense multiplication of their fortunes, and made the incomes of many of them aggregate sums far beyond the legitimate demand of mortal, and this to the plain deprivation of the public.

Mark, too, the influence of the landlord in legislation. Note the privilege which attends his claims even in America.

In Great Britain in 1692 the tax on land was one fifth of its annual value, now it is about one fifth of that fraction. Landlords have thus grossly evaded their fair share of taxation. And note what horrid suffering and violences, often unpardonable, have been necessary to give Ireland such measure of land-reform as she enjoys to-day. The agitation against primogeniture and entail grows constantly in force in Great Britain, and the reform begun in Ireland and hastened there by differences in race and religion between landlords and tenants must of its justice spread to the sister island in time.

The complaint against property has, I think, been unduly directed against land, perhaps because land used to be the chief form of wealth. Real estate may present the most evident cases of abused privilege, but the main social difficulty, it appears to me, is the undue accumulation of wealth of any kind. The land of the world is certainly limited in quantity, but so are other forms of wealth: houses, mills, machinery, railways, and merchandise—all these, though vast in amount, are something short of infinite; and while land, as in America, is freely exchangeable for these other things, no special harm attaches to undue possession of it. And if it be said that these other things differ from land in that they can be indefinitely increased in amount, such an increase may be fairly compared with the settlement of barren territory in old countries, or of virgin soil in new. The forms of wealth other than land, while practically quite as limited in quantity, are quite as necessary to human life, so that, in their arguments against excessive

holding of land, political economists have perhaps paved the way for a more radical discussion of the rights of property than they ever anticipated.

No landlords have ever been more oppressive to a community, or levied more odious exactions, than the merchants and speculators who in the United States corner coal or pork, or the manufacturers who, secure in a close, protected market, combine to extort from consumers an exorbitant price for oil and chemicals. Canadian cotton-mills, which before the rise in the tariff, effected in 1878, were paying about eight per cent in dividends annually, since then have earned double and treble such profits at the public expense. The broad question of property, not the narrow one of land, is up for discussion, and it can not be dismissed with inadequate treatment. At the dawn of the present manufacturing era, in the days of Watt and Arkwright, about a century ago, there was a hope widely prevalent that the conquered forces of nature, acting through the ingenious machinery and processes so rapidly brought forth at that time, would greatly improve the lot of the poor. That hope, so creditable to the hearts of the men who entertained it, remains unfulfilled. The poor, it may be admitted, have been improved in condition, but have they proportionately shared in the enormous aggregate increase of national wealth? The development of the past century's manufacturing and trading industry in the existing moral and social circumstances has been attended by the constantly growing contrast between colossal fortunes on the one hand and the earning of a mere livelihood on the other. The masses toil as hard as ever, for all the steam-engines, the railways, and complicated machinery applied to every form of industry. The chief result, and certainly an unsatisfactory one, is that the luxury of a few increases. Within recent years palace-building has begun in America, and sums have been lavished upon the homes of railroad and mining kings to an extent equal to the making cheerful and wholesome whole quarters of cities occupied by the squalid tenements of toilers. With industry highly specialized, and becoming more and more so year by year; with the web of a credit competition continually increasing in complexity and liability, leading to panics more severe with every recurrence, there is manifest danger to property—danger, because these stresses of business entail suffering beyond description among the working-classes, and, under some sharp distress, they may make a savage and ill-considered attack on capital. Let Pittsburg and Baltimore justify the assertion.

Popular discontent has in all ages been a dangerous thing, but how much more so than ever now, when a numerical majority—that is, the poor—control legislation, elect the executive, and levy taxes! In the last analysis the rights of property depend upon the popular will, and the people can readily modify existing rights in what they may take to be the general good. Fourier and Saint-Simon did not speak to

a nation enjoying universal suffrage, nor were Utopias ever before preached to men who might practically attempt their establishment. The wide diffusion of popular knowledge through the schools, the press, and the platform, in these latter days, has made the discussion of such questions as that before us very general and very earnest. Workingmen's newspapers of wide circulation debate the *pros* and *cons* of the land and other problems fearlessly and with much good sense. The extension of the suffrage and the progress of political reform have taken such subjects out of the small circle where only speculative thinkers used to discuss them, and brought them home to the great masses of the working population, into whose hands the reins of legislation must more and more directly come. Trades-unions have made workmen sensible of the power of union and organization, and the benefits they have derived from their combinations have led to a wide-spread capacity for acting in concert scarcely known among them until this generation.

While in England and on the Continent of Europe property is much more unequally held than in America, it is evident that there are forces at work in the New World which are creating problems similar to those in the Old. Competent observers declare that wealth is passing more and more into the hands of the wealthy, the manners of the wealthy class are improving—they are gradually becoming an aristocracy in all but name; and, as the societies of the older cities become more and more cultivated, I think we may see a large proportion of wealthy families retaining their possessions for generations as they do abroad. It used to be thought that the sons or grandsons of rich Americans could be relied upon to give back to the community their inherited wealth through demoralization and incompetence; but that reliance is proved baseless in a noteworthy proportion of cases in New York, Philadelphia, and Boston. Fifty years ago the wealthiest man in America had a fortune of ten millions, let us say; now, the wealthiest citizen of the United States has a fortune estimated at from ten to fifteen times as much; and the proportionate increase in the extent of fortunes of the second and third magnitude has been similar. Has the wealth of the average citizen increased in anything like this degree? And such democratic social intercourse as we possess has its dangers—the intermingling in society in this country of people comparatively poor with those comparatively rich implants in those of restricted incomes a desire to live expensively, which would less often be the case were class lines as distinctly drawn here as they are across the Atlantic.

Into the question of the social advantages to a community of a very wealthy and leisured class I do not enter, but in passing would note that perhaps the worthiness and manliness, as a rule, of the British aristocracy have done very much toward their privileges being respected in these times of radicalism. And contrariwise, the sharpest

disgust against property has been expressed in the democratic far West, where refinement unpossessed of wealth jostles with the coarse ostentation of the bonanza kings.

The conquest of the weak by the strong, which must date from the very dawn of trade as from the first morning of life, has been more remarkable than ever within the last generation or two. The new methods of rapid or instantaneous communication bring vast commercial fields under the scrutiny of the keenest business intellects, and the local knowledge of the small trader is overborne in competition by the capital, adroitness, or unscrupulousness of his metropolitan adversary. Modern business economy favors vast organizations which absorb feeble competitors, and convert men who were independent principals into the servants of a master-will, whether controlling an individual firm or a corporation.

The danger to the public interest in the growth of great monopolizing companies is proved in the case of the Western Union Telegraph Company, which had nominally a capital of eighty million dollars a year ago, upon which it had to pay dividends. Nearly fifty-five of the eighty millions was, however, fictitious stock—water, in the language of Wall Street (see "North American Review," March, 1881). In the "Atlantic Monthly" for March, 1881, it is stated that the Standard Oil Company refines nineteen twentieths of the coal-oil of the United States, and robs the public of eight and three quarter cents per gallon by its monopolizing control. And what makes the abuses of property so difficult of legislative reform is that monopolists in their schemes avail themselves of business rules which, in their ordinary working, are legitimate, and can not be safely interfered with. If a Legislature enacts that a company shall not divide more than ten per cent annually as profit, that company is sold out to another, and both of them can pay dividends up to ten per cent. Competition is abolished by exercise of the right of purchase and sale, whereby competing railway, steamboat, or telegraph lines may be controlled by a single capitalist or syndicate; the operation being aided by banking facilities whereby stocks can be pledged as collateral security for loans equal to eighty or ninety per cent of their market value. The presidents and directors of great companies who organize such operations, and who have at all times special and early information of the influences likely to affect the value of their stocks, either directly or through agents, and the margin system, frequently add large sums to their fortunes at the expense of ignorant shareholders. The ordinary operator in Wall Street loses simply because he plays against men whose dice are loaded. The tendency to corporate and wholesale management so plain in the vast enterprises of the country is manifest in the less noticeable. In the Western States the factory-system has invaded the corn-fields: grand culture, as it is called, has come into vogue; large capital, elaborate steam-machinery, and regiments of laborers, are cultivating the

soil, and not scores of independent families with their personal interests and all the healthy influences of an independent, self-reliant struggle. In manufacturing and trading, as well as in farming, the strong large companies and houses are absorbing the weaker, and the fortunate ones who head the movement tend to become proportionately fewer as the process goes on. Every child now born into the world's theatre finds most of the best seats taken, and a good many of the second best. In all this I think there is danger, for which it is becoming necessary that preventives were thoughtfully sought.

Without deliberately facing the problem of *have* and *want*, there has been for ages a lurking, unconscious impression abroad that the differences in human fortunes are apt to injuriously widen—that the very poor have a moral claim upon the rich ; that somehow, if human affairs were once to be placed on a basis of right, there would be none very poor, and so roundabout justice has for long been calling itself charity. The English poor-laws, dating from Elizabeth, which guarantee the natives of a parish support by the parish, is the most noteworthy example of this. Perhaps the next most striking example is our modern state education, which goes beyond the enforcing on a parent of his child's education—as it enforces its provision of food, clothes, and shelter—and, as it seems that these latter expenses are all the parent can usually bear, the child of the poor man is sent to school chiefly at the charge of the rich and well-to-do. The attempt at rectifying, however crudely, somewhat of the current social injustice, reconciles many to the measure who would otherwise oppose it on the high grounds of liberty and the inviolable responsibility which should remain with a parent—for why should bread not be given to the children by the state as well as books ?

Besides public-school education, there have been many commendable attempts within recent years at reducing the glaring inequalities of fortune so common and so undesirable. Public parks, libraries, museums, picture-galleries, and hospitals have been established with public funds for the popular good ; and wealthy men have given large gifts to them, recognizing the responsibility of riches and doing something for the toilers who have brought their accumulations together. Yet if we are to expect more of justice in the institution of property as time goes on, we may expect to see the circle of charity recede as opportunities for its exercise diminish.

Having briefly and very imperfectly stated some of the evils which attend the present methods of distributing and accumulating property, let us proceed to glance at the principal remedies suggested for their correction. The formal proposals for the righting of the wrongs of property have begun usually with land. In Great Britain not only reformers and philosophers, but parliamentary commissioners have again and again pronounced against the laws and customs of primogeniture and entail. These laws and customs are held to lead to unduly large

estates—estates so vast as to be unwieldy in management, interposing factors and stewards too often between landlord and tenant; these vast estates yield incomes culpably great and so enormous that their recipients are often indifferent to improvements in farming in comparison with proprietors of small farms, and much land is wasted by being held for mere sport. When the holder of an entailed estate quarrels with his heir, the land suffers, that the personal property which may be freely bequeathed may be increased. Such quarrels, if we are to follow the experience of common life, are usually due in part to qualities in the heir which would make him less worthy of the estate than some relative or kinsman to whom the holder might bequeath it were he free to use his judgment.

Mr. Kinnear, who has written a most sensible book on the subject of property in land, argues convincingly that the diffusion of property rather than its aggregation is desirable, holding that nationally property will be found to be accumulated more rapidly in the former case than in the latter, while at the same time comfort and content will be more common. He speaks from wide experience in Great Britain, France, and the Channel Islands. Mr. Kinnear suggests that there be limits placed to the amount bequeathable to an individual, so that very large estates may become divided. In common with the majority of competent observers, he prefers the French tenure of small parcels of land to the British tenure of great estates, but he regards the French compulsory division of the bulk of a property at a father's death among his children as wrong: were the father free to will to whom he pleased, the moral effect would be beneficial.

Children grow disobedient and unfilial when they know they can not be set aside. And speaking of wills, the custom of making what should be naturally one of the saddest events in life the occasion of coming into a father's estate is severely commented upon by the supporters of Russian and other communal systems of tenure. In the Russian *mir*, when a young man becomes of age, he enters into the enjoyment of a share in the common estate, and the effects of this difference are said to be observable in the stronger family feelings which the Russian peasantry cherish in comparison with their Western brethren.

The sad experience of King Lear and the painful presence of the gaping heir are both avoided by those sensible men of wealth who are their own executors to as great an extent as may consist with the reserve of a personal competence.

The individual holding of land as in France, Germany, England, and America, has been opposed by a great many thinkers and popular leaders. The chief objection lodged against it has been that land, being as absolutely necessary to human subsistence as air and water, it should be as free from monopoly as these; for as the accumulations of a single holder go on there is risk of his being able to drive people forth

where monopolists like himself do not exist, or, in conjunction with other such monopolists, order people off the face of the earth!

The second objection made to the present nearly absolute holding of real estate is that, particularly in America, and in Great Britain during the past century, the growth of population, the advance of manufacturing towns, and general progress in trade and commerce, have had the effect of enormously enhancing the value of land, increasing rents, without owners having given the community any equivalent whatever. Now, this unearned increment, as it is called, has bestowed upon some British noblemen and American land-owners many millions of value conferred by the mass of the people. This evident injustice is especially pressing in America, where there can be no doubt that, if the tenure of land remains as it is, the value of land apart from the improvements which labor may effect upon it, will be multiplied greatly within a century. Various remedies have been proposed to correct the evil.

The nationalization of land as suggested by Mr. Herbert Spencer has special reference to the United Kingdom. He would have the Government buy all the land from its owners at current market rates, and let it on competition. Mr. Fawcett, in his criticism of this suggestion, estimates the value of British lands and houses, apart from mines and railways, at £4,500,000,000. This enormous sum exceeds by six times the British national debt, and the raising of so large a sum as a loan in purchase would probably enhance the rate of interest one per cent beyond its present rate, and beyond the present rate of return received as rent. An annual deficit of £50,000,000 is calculated as the probable result of carrying out the proposal. Besides the special value attaching to individual possession, a value forming part of the current prices of land would be abolished when nationalization took place, and purely economic rents, minus the expense of an objectionable government control, would form the revenue to be credited against the interest on the purchase-money.

One of the leading pleas for nationalization of the land is the deprivation suffered by those who own none; but could not complaint be directed with equal propriety against lessors by all other citizens who would have to accept subleases? The sole benefit that could be hoped for from this scheme of nationalization would be the absorption in coming time of the appreciation in value due to increased density of population and other causes. This appreciation, if it takes place at all in the generations of the near future, is not likely to be other than moderate in the United Kingdom.

Mr. Henry George, of San Francisco, in his striking book, "Progress and Poverty," advocates much more heroic treatment of the evil of unearned increment. The constantly increasing tax of landlords, as tenants multiply and advance in industry, he regards as the main reason why a wedge seems to be dividing more and more widely the rich

and poor. In his distant State he has seen land taken up by speculators and held untilled for years, that it might advance in value by immigration—settlers by such action being far too widely scattered for their private good or the general welfare of the State. Taking the ground of natural right, and following Quesnay and others, Mr. George declares that except in the improvements due to labor no man can have a valid title to any part of the earth's surface. He therefore proposes a tax on real estate which shall be equal to its rental as unimproved land. In defense of this virtual confiscation in its results, he declares his opinion to be that his tax would render any other unnecessary, so that, in exemption from duties and other government levies, property-holders would receive a considerable palliative for the loss caused them by his discovery of the invalidity of their titles. The owners of town and city lots whereon buildings exist, and owners of improved farms, would retain the whole value of buildings and improvements, so as to be left with a large proportion of their former wealth. Objections bristle on all sides against Mr. George's proposal. First, he takes no note of the pretty general diffusion of real estate among the American people, property which all except a few of the whole population regard as real and substantial in a special sense. The confiscation of land, in past years freely exchangeable for other property and not generally held to-day by the enjoyers of very much unearned increment, would be resented by the common sense of the people; and the conscience of the needy classes, once weakened as to the validity of the tenure of one kind of property, might, under pressure of want in a commercial panic, indiscriminately attack all.

Most of us feel that the millionaires have too much even for their own good, yet any confiscation which might begin by depleting plethoric purses might end by larceny from very slender ones; and a movement ostensibly begun on grounds of public justice might, by additions of envy and the spirit of common theft, degenerate into wholesale pillage. Besides, how could a government like that of the United States be trusted with so vast and difficult a business as assessing all the land within its borders at its value—that is, at its market price, minus improvements? But the injustice of unearned increment in land remains with us still, and makes us wish that in America, on original settlement, the leasing for long terms had been established instead of absolute sale or gift by the Government; and also directs attention to the advisability of taxing the increase of value in land due to advancing population, say to the extent of one half such increase, in cases of depreciation just rebate being made. Some perception of the evils which Mr. George has beheld and would endeavor to correct, led a few years ago to the forming in Melbourne, Australia, of a land-reform society, which intended to urge on the Government the plan of leasing its lands instead of selling them to men who were reproducing in the colony some of the worst features of the English land-

tenure. In Java the Dutch Government leases plantations to a vast extent, and the plan works well there.

In Germany, the agitation against the existing laws and privileges of property has taken the form of socialism; the schemes of thinkers and closet-students have been popularized by press and platform until now the Socialistic party sends a large representation to the Reichstag, pressing measures upon the Government which a generation ago would have been deemed revolutionary. Much heated discussion has recently taken place in the national Legislature on the proposal that the Government should undertake the manufacture of tobacco; and if the state should manufacture tobacco acceptably and economically, why not cotton and wool? The beaucracy and strong paternal Government of Germany perform so many functions left in England and the United States to private enterprise, that the people in times of business depression look to the Administration for measures of relief instead of to their own efforts.

It seems to me that socialism is an evidence of the constantly rising dislike among the masses to the main advantages of competition and new business economies being enjoyed by the small class of capitalists. How far state control may allowably be invoked as a remedy in fields wherein individual exertions have been employed is a question warmly debated. One school of thinkers, led by Spencer and Bastiat, hold to *laissez faire*, and wish the operations of government confined to the narrowest limits—the maintenance of order and the enforcing of contracts—leaving individuals the utmost scope to think, express themselves, and act; the opposite school, among whom as an able exponent may be named Mr. Cairnes, hold that individuals, while following what they believe to be their interests, may not conceive their interests truly or in relations harmonizing with the general good, and that therefore some general control by the community of the actions of its several classes and members is most desirable for the correction of such practices and pursuits as are inimical to the whole body of the people, though pleasant or profitable to a few. This is said by Mr. Cairnes and others, not in advocacy of the general state direction of industry, but only in qualification of the sweeping theory that individuals, each doing his own work for its own reward, or seeking his pleasure in his own way, unconsciously contributes to the highest well-being of the community. Mr. Cairnes thinks the individual in society should be like a musician, who, in playing his part, looks chiefly to his own score, but occasionally glances at the central conductor so as to keep proper time with his fellows.

State socialism is not a living question in Great Britain or America; in Great Britain, however, the Government has notably added to its functions of late years: it has absorbed the telegraph service and the savings-banks into the post-office, and there is some expectation that the railways may also come under Government control. Mr. Brassey

believed that much waste of capital would have been prevented had Government controlled the English railways from their inception; unnecessary duplicate lines would not have been built, and their heavy cost in construction and maintenance would have been saved. Some forms of industry, like railway transportation, where free competition can be seen to lead to public waste, would seem to come appropriately under state control, provided that, as in Great Britain and Germany, the Government is administered honestly and intelligently. Advocates of state-controlled industry point to the danger, particularly in America, of railroad and similar monopolies robbing the people, but the people are not yet satisfied that their risks are not less as matters stand than if Washington officials bought supplies, constructed time-tables, and engaged the servants. Mr. Albert Fink, railroad commissioner, in ability and character the chief American authority in railroad questions, gave before the Committee on Commerce in Washington, last March, some very interesting explanations of the difficulties of railroad management. He showed that the intricacies of the business were plainly beyond the mastery of a government board, and he attributed the sources of such valid complaints as are made against railroads to their lack of mutual co-operation and good faith. He suggests the appointment of a commission to investigate the facts adduced in substantiation of complaints against railroads; such a commission, at the close of its labors, to recommend, if it thought fit, the establishment of a permanent commission for the best devisable supervision by the state of railroad transportation. Mr. Fink stated that a board of arbitration among the railroads themselves, with power to enforce agreements and maintain good faith, would abolish the main evils which beset the business. He drew attention to the fact that, while agitators desire to reduce the earnings of the few roads in the Union which pay more than the ordinary return upon investments to that rate, they are not desirous of making up from the public treasury the deficits met with in operating many of the lines of great public utility.

Modern business is unquestionably, in important departments, passing from individual to corporate management, particularly as the art of conducting companies becomes better understood year by year. Town and city corporations in Great Britain have long since absorbed with advantage the business of water-supply, and have, within recent years, successfully undertaken the manufacture and supply of gas; and why, if ten men agree to conduct a business, may not ten thousand, or the large majority of voters in a town, or, for that matter, in a country, resolve themselves into a company, if they think there are good prospects of profit ahead, and conduct any business whatever? Experience alone can decide whether the expectation of profit is baseless or not.

Less ambitious than state socialism, and more practical, is co-oper-

ation, which is fast revolutionizing British retail trade, but which is very slowly attacking the pressing problem of production. We can only expect the conflict of capital and labor to cease when labor, by thrift, has saved capital and participates in profits. To begin co-operative production, only picked men can be useful, for, in the present condition of workingmen, there is not generally diffused the intelligence and character necessary to selecting proper leaders and trusting them.

The difficulties of co-operation are the main difficulties attending the reforms of property. No laws or methods tending to replace a millionaire by ten men of a tenth his fortune may touch the question of how extreme poverty among the masses is to cease. The elevation of the poor chiefly depends upon themselves, upon their intelligence, their ascertaining the real conditions of life by a sensible plan of education, and then fulfilling those conditions by hard work and self-restraint. No people that spend $600,000,000 a year on drink can excite much sincere pity for their poverty. No people who marry without regard to their ability to maintain wives and children can look for substantial aid from Legislatures. Leclair, the house-painter of Paris, has demonstrated that honesty and forbearance are all that are needed, under available direction, for workmen to appropriate the profits they so heartily grudge their employers. Evidences abound that, when the time comes that workmen are fit for co-operation, able men from among their ranks will take their places at the head of manufacturing associations, and therefore the deprivations which are suffered by the present systems of employing labor await abolition with the development of conscience and intelligence among the toilers.

The material gain achievable by directly interesting workmen in the results of their labor must soon be expected to awaken among both employers and employed a desire to test, on a large scale, the partnership plan so eloquently advanced by Mr. Holyoake and others. If the profits now appropriated by the heads of great companies and firms are felt to be more than just, the moral condition which makes the profits so great is one which it lies with the contributors themselves to lift and improve.

Formal methods of dealing with the problems of property may be expected to do much less to equalize disparities of fortune than an improvement in social morality throughout all classes of the people. The great monopolists derive much of the strength of their position from a debased public sentiment, which condones their methods and admires their success. Often the shippers who complain against the tyranny of a great steamship or railroad line themselves practice rules similar to those against which they cry out; they take advantage of scarcity—at times an artificially created scarcity—to extort extra profits; and, as a railroad monopoly makes its traffic bear all it will, the little monopolist, in the shape of manufacturer or trader, makes his

customers pay him as much as he can, when circumstances give him the power of demanding unusual prices. An elevation in social morality would make conduct of this kind less common than it is, and would inevitably have some influence in restraining the greed of great monopolies. In America, with its limited past, wealth has an excessive social power, its pursuit is the business of nearly all the strongest intellects, and its marvelous growth in the country at large from year to year constantly tends to make it a more and more decided object of ambition. The ideal of a vast number of the people is wealth, and scarcely any price is thought too great to pay for it. If any improvement of this ideal is possible, it lies with teachers of morality and right thinking to effect it. Whether on the school-rostrum or the platform, in the pulpit or the editorial chair, or, above all, in the home, the aim of life should be taught to lie rather in the development of heart and conscience than in the accumulation of vast estates—more in the growth of honor and manliness than in the growth of those arts which gather wealth but stunt and paralyze the faculties of true enjoyment. The low idea of the subordination of life to the means of living is at the root of most of the problems of property. One of the chief impulses in the pursuit of wealth is the desire of obtaining public admiration and applause; if these are intelligently awarded much will be done to curb the unscrupulousness of those who gather together a great deal more than they can enjoy, in some cases heaping up sums far outbulking the accumulations of any previous age. And much will be done toward making efficient, in the prevention or punishment of the abuses of great properties, such legislation as may be applicable.

THE ETHICS OF VIVISECTION.

By Dr. SAMUEL WILKS.

SINCE many writers opposed to the practice of experiments on animals have based their objections entirely on moral grounds, and thus made the question of vivisection an ethical one, I have been anxious to know what laws they have discovered for our guidance on this vexed subject. They discourse on cruelty, on immorality, and on the rights of animals; but these expressions are so vague that they fail to afford any basis for legal or public action, or, if there be any attempt at definition, it is with the object of making these terms conform to a foregone conclusion on the very point under discussion. Thus it is constantly asserted that physiologists feel at liberty to torture animals at their pleasure, without regard to the "higher dictates of humanity" or to the "laws of morality." It is thus implied that there exists among the public some principle of conduct toward the

lower animals which has no place among experimenters. They speak as if, standing on a higher platform and beholding all creatures from a superior position, they could frame a code of laws which should have due regard to the rights of animals, and govern our own conduct in all our relations to them. This position is altogether fallacious: man can not disconnect himself from the animal world, and can not define its rights. It must, therefore, be abandoned as altogether untenable, and the subject discussed from a totally different stand-point. Our relation to the animal world can only in a very qualified sense be regarded from an ethical point of view; much in the same way as eating and drinking may be spoken of as questions of morality when moral considerations exert their influence over the amount and kind of food which we consume; this, however, can not hide from us the fact that the subject of digestion is fundamentally a physiological one.

The duty of man toward animals as an abstract question is from its very nature insoluble; it can only be partially answered on the grounds of expediency, and these will vary according to age and nation. We should, rather, ask what is our relation to the lower animal world, and in what place in that relationship can moral considerations come into force? In endeavoring to form a judgment of this relationship we must take facts as we find them, for the attempt at an explanation is trying to solve the riddle of our existence, and leaves us still with "the burden of the mystery of all this unintelligible world."

In seeking a solution of such a question as our duty toward inferior creatures, we must take into account man's animal nature; he is of the earth, earthy, and depends for his existence on the living world around him. Like many other creatures, he has to prey upon the lower animals for his subsistence, and although he may not often, after the example of some monsters of the deep, swallow small fishes by the mouthful—as in partaking of white-bait—yet, like the other carnivora, he hunts his prey and stealthily lies in wait for his victim. A large part of the existence of the lower animals is employed in search for food, or in protecting themselves from the assaults of their more powerful foes. Their exquisitely keen senses are put into full play to seek out their prey, or to place them on their guard against their more subtle enemies. Paley could discourse on the design manifested in the claws, teeth, and lithesome movements of the tiger, so well adapted for the capture of its victim, and with equal discernment portray the form and slender legs which enable the latter to escape its foe. It is necessary to picture Nature as we find it, or we may fall into the error which we see pervading so many recent writings—viz., that nearly all the miseries and pain inflicted on the lower animals arise from their connection with man. If we remember how many animals prey upon one another we shall realize the vast amount of pain and suffering ever existing among highly organized and sensitive creatures. None of us can measure the agonies of the slow death of an animal who has escaped mangled from

his enemy and been left to linger on a sunburned soil, with hunger unappeased and thirst unslaked. Most of us have seen the picture of the dying camel in the desert, glancing up with fearful eye at the vultures hovering above him; and the cat playing with the terror-stricken mouse is to many a familiar sight. Over other and grosser cruelties practiced by one animal on another, it would be best to draw a veil. A far pleasanter picture is it to contemplate the beauties of Nature, the glorious vegetation, the singing of birds, the gamboling of the lambs in the meadows, or the wild herds in the prairies; and yet there is no escape from the fact that animals practice toward one another nearly every human crime. There is the bright side of the shield, but there is the other which shows that "the whole creation groaneth and travaileth with pain until now."

Man, like other carnivorous animals, derives a pleasure from hunting his prey; and, indeed, many of the gratifications of life are dependent upon his animal instincts. In a primitive condition, while the woman is at home providing for the household, the husband is away in the forest or on the mountain seeking for food, and finding a keen exhilaration in the chase. In a higher state of civilization the instinct still remains; for, although the butcher may supply the meat, the sportsman still pursues the game; or if the fish-monger sells the salmon, the zest for catching the fish still exists. A man does not kill his own sheep for dinner, but he approves of the act; the most honest and guileless lady will not hesitate to eat the bird for the capture of which cunning and treachery have been employed. It would seem, from these examples, that a carnivorous animal like man can not frame a code of laws in relation to his inferiors, or determine the rights of the lower animals, on any Christian or other ethical principle, such as "to do as we would be done by." Up to recent times we have acknowledged no other law than "might is right." For I am not aware that society or the public voice has put any restraint on man's desire to kill whatsoever animals he pleases for his food; as for clothing, he may capture any creature he fancies, and steal the skin, coveting it the more the handsomer its coat; while society has not hitherto placed any limits upon his greed. We not only eat for necessity, but we foster and pamper our appetites, we breed creatures for our uses, and, when fit for our stomachs, kill them, doing also what humanity has never yet blushed at; first mutilating them and unsexing them. It has been truly said that in this sad world one of the greatest gifts bestowed on the animal creation is the relation of the sexes; and the singing of birds, the building of nests, the mating of animals, have given rise to much of the poetry of Nature. But it has been left for man to make herds of beef, and flocks of mutton, and horses whose only function is to drag our carriages. One might ask, in these sentimental and æsthetic days, whether one sigh of pity has ever been raised over these poor maimed creatures? What do those who talk of the rights of animals say on this

matter? or how does the ethical question apply here? Was the morality of the business discussed when nearly the whole family of whales was exterminated for the sake of their oil, or whenever troops of horses have been exported to engage in our quarrels and perish on the battle-field? If a horse could define his rights, would he admit the necessity of his going round and round in a mill the live-long day, or dragging a tram-car with the never-ceasing jangle of bells in his ears? Would the thousands of God's creatures in India approve of being called "vermin," and exterminated at so much a head? It is clear that, as regards food, clothing, mutilation, or work, there seems to be no other rule guiding us than "might is right." We have exercised the dominion given us over the beasts of the earth and fowls of the air as tyrants.

Now, when all this is said and admitted, we recognize over and above our animal instincts a higher nature within us—pity, love, compassion, and duty toward other objects; sentiments, indeed, which seem almost antagonistic to our lower life and to the proclivities of our fleshly body. This higher aspiration has ever been regarded as one of the best evidences of man's spiritual nature. We observe that a cultivated man is obliged to find a substitute to kill the sheep for his dinner, or to employ the necessary cunning to catch his game, since he could not practice deceit himself, nor nerve his arm to strip the Arctic animals of their skins to clothe himself. But although he does not imbrue his hands in blood, and although he dismisses from his mind the question of the animal's "right" to its own skin, he can not discard his own animal nature by appointing a substitute to perform actions in the result of which he participates. When, therefore, the question of the relationship between man and animals is considered, the fact that man is a killing and hunting animal himself lies at the very foundation of this relationship. Where, then, it may be asked, do the higher sentiments of which I have spoken come in? A ready answer is, that all these practices toward the lower animals are admissible and necessary for man's existence, but that *cruelty* should be avoided. This word, in common use of late, appears to signify the giving of unnecessary pain, but it still remains ambiguous unless the word "necessary" is defined. One may gather from various writings that "necessary" is equivalent to "advantageous to man"; for example, the word "cruelty" would be applicable to the case where a half-starved horse is made to drag a cart too ponderous for his strength, but it would not apply to the case of the same horse dragging a heavy cannon over a mountain for the safety and glory of the nation. What, then, is necessary pain, and what unnecessary pain or cruelty? If necessity is construed, as it is at present, to include not only the procuring of food, but man's enjoyment and general advantages, it is obvious that the question must have ever-varying answers. There are a few persons, vegetarians on principle, who would not kill animals for food under any consideration;

there are others who would not take their lives for pleasure. Past generations have approved of cock-fighting: there may be a future generation who will discountenance pigeon-shooting, and will regard that age as barbarous which could witness without disgust the bleeding carcasses of sheep hanging up in our most fashionable thoroughfares. The spirit of the age and the feeling of society for the time seem to determine what amount and kind of pain and suffering people will allow to be inflicted on animals and what they will disallow. The very valuable Society for the Prevention of Cruelty to Animals does not seem in its operations to offer a solution of the question. It would seem that most of the examples of cruelty which the society publishes are those where the public gain nothing by the act complained of, and can therefore afford to prosecute. For example, I have heard "shame" called on a carman who was endeavoring to make a horse draw a coal-wagon along the slippery pavement of Bond Street; and this exclamation came from a gentleman who on turning round might have seen the quails and larks closely caged for his table, and the dying and writhing lobsters waiting to end their miseries in a pan of boiling water. It would almost seem that the infliction of pain is allowable if approved by the majority, and that it is not allowable and constitutes cruelty if disapproved. In other words, cruelty depends upon the public estimation of its utility or inutility. One is forced to arrive at this conclusion, for the more one thinks over the rights of animals, or the ethical question of our treatment of them, the less does it appear that any considerations framed upon rights or morals have ever influenced mankind in its conduct. It is possible that some vague ideas respecting man's duty to animals may be floating through different brains, but those ideas have never become concrete.

It being admitted that man has a power, if not a right, over the lives of the lower animals, the question arises, Where should this right be limited, and at what point should our animal instincts, appetites, and wants be restricted? Utility or advantage seems to be the gauge used by the majority of persons. The question, therefore, between the anti-vivisectionists and their opponents appears to be a narrow one. The former assert that the pain inflicted on animals is out of proportion to the advantages obtained; Lord Coleridge says as much in his well-wrapped-up dictum. We, on the contrary, declare that the importance of experiments can be shown to be overwhelming in comparison with the pain inflicted on animals for this and other objects. The lofty phrase that "knowledge is unlawful knowledge if it is pursued by means which are immoral" must be analyzed to understand its meaning. As it is made applicable to vivisection, it is clear that "immorality" means "giving pain to animals"; and his lordship's statement would run, "All knowledge is unlawful if obtained by giving pain to animals." Whence it follows that, as it is allowable to give pain to animals for various purposes, it is only unlawful to give pain when the pur-

pose is knowledge. I see no other interpretation to put upon his words, and thus he places himself entirely at one with the rest of the anti-vivisectionists. These writers select out of foreign works all the horrible pictures they can find, and most unfairly ignore all those important experiments made by the aid of the most trifling operations under chloroform, and which have proved to be of inestimable benefit to animals and men. Lord Coleridge, although protesting against the charge of antagonism to science, unwittingly shows how profoundly he misunderstands the methods of scientific men, and consequently falls into the same error as his more ignorant friends. However little sympathy he may have with science, one would have thought that Whewell, Mill, Jevons, and others had clearly demonstrated that the methods of science can only be reached by accurate observation and well-devised experiment. I am afraid, therefore, that scientists will scarcely consider that man to be among their allies who believes their method is "to perform a hundred thousand experiments in the hope that some new fact may turn up." But this is only an example of the misleading nature of the statements and expressions of the anti-vivisectionists. This very term implies that their opponents are vivisectionists; much in the same way as, if a certain sect of vegetarians were to style themselves anti-sheep-killers, all the rest of the world would be sheep-killers, and this opprobrious word would be employed toward any lady who was seen eating a mutton-chop. The two cases are exactly analogous, for among the thousands of medical and scientific men who see the advantages of making experiments on animals there are scarcely twenty who would be willing to undertake operations of so disagreeable a nature. Just as the sheep-killers are those only who would protest against any laws being made to prevent them eating animal food, so in like manner the "vivisectionists" are those who maintain that legislation should not prevent a few physiologists performing the experiments which they judge necessary. What is asked by the vivisectionists is, that the whole power of the law should not be brought to bear upon a handful of accomplished men who are engaged in the service of science and humanity. They do not object to laws being made to prohibit incompetent persons from experimenting.

The difference between a dozen anti-vivisectionists and a dozen scientific men can not possibly turn upon a moral question such as dislike of cruelty; and, therefore, if the one can look upon an animal injured and bleeding with serenity and the other not, it would be owing, as the former party assert, to usage or habit. Let this be admitted, the converse is also true, and it may be safely conjectured that much of the opposition to experimentation is due to the unpleasant picture which the subject presents to the imagination. The difference between sensitiveness and compassion, or active benevolence, was long ago pointed out by Coleridge; but for this difference, Howard would be justly called the most hard-hearted of men. A lady shrinks with

horror from treading on a black beetle, but is only too satisfied to hear that the cook has exterminated the "vermin" by poison or boiling water. But lately an excellent example of a personal sensitiveness being mistaken for compassion has been witnessed in the case of the sale of the elephant. If the word of the Council of the Zoölogical Society can be taken as true, it was believed that "Jumbo" would be far happier traveling among his kin than leading a life of solitude in London. Yet, in spite of this statement, all the kind-hearted people have been sending their subscriptions to enable the society to forego its bargain, since they and their children can not bear to part with their favorite. It is like the frequent example of a mother preventing her son taking the voyage prescribed for the benefit of his health because her feelings can not allow her to part with him.

After eliminating all that is irrelevant and false, the question between experimenters and anti-vivisectionists appears to be a simple one. The latter declare that experiments are attended with great cruelty, and the results are of little or no good; they should therefore be disallowed. The former deny the truth of the proposition, and maintain that it is tyranny to put in force the power of the law to prevent a few, a very few, men of known reputation as trained physiologists performing occasional experiments, often unattended by pain, for the sake of advantages which they believe to be enormous. To endeavor to make vivisection a question of ethics, when moral considerations are altogether and confessedly ignored in a thousand other instances, is clearly illogical, and obviously prompted by an undue bias. In other words, the selection of the so-called standard of "morality," or of the "rights of animals," by which to measure the permissibility of physiological experimentation, is undeniably a prejudgment of the real point at issue. —*Contemporary Review.*

BORAX IN AMERICA.

By W. O. AYRES, M. D.

BORAX is now well known to occur in very many of the salt-springs in the Coast Mountains of California. But in only two places has it been found in large quantities: these are Borax Lake and Hachinhama (pronounced *Hah'-chin-ha'-ma*), both being in the immediate vicinity of Clear Lake, about eighty miles north of San Francisco.

Borax Lake is a shallow pool intensely of alkaline water, without inlet or outlet, and of course its extent depends on its reception of rain-water. After an exceptionally wet season it has a length of perhaps a mile and a half, with a depth of eight to ten feet; after an excep-

tionally dry season, on the contrary, it shows sometimes no water, the muddy bottom being covered with saline incrustations. When it has a length of three fourths of a mile, with a depth of four feet, being perhaps its average condition, the water holds in solution 18·75 grains of solid matter to the ounce—·039 of its own weight. This consists of salts of soda, in the following proportions: Sodium carbonate, ·618; sodium chloride, ·204; sodium biborate, ·178.

But this alkaline water, exceedingly rich as it is in borax, constitutes only a trifling part of the commercial value of the lake. In fact, it has never been turned to account at all in the manufacture of borax, though such use of it is entirely practicable, as the statements to be presently made in relation to Hachinhama will show. The muddy bottom of the lake was found, immediately on its discovery in 1856, to contain borax in crystals, in quantities most astonishing.

These crystals, being tested by various workers in iron and steel, were pronounced equal to the very best of refined borax. They are, in fact, pure biborate of soda, without any other impurities than the mud mechanically entangled with them in their process of crystallization. They correspond to the native borax of other localities, designated as *tincal*, but yet are decidedly distinct from it. In fact, no such crystals as those of Borax Lake have ever been found in any other locality, and there are several points in connection with their mode of formation, and even their very existence, which are by no means easy of comprehension, as we shall see.

Although the discovery was made, as already stated, in 1856, no practical development of the lake was begun until 1864. From this time it was pressed vigorously until 1868, when it ceased, not from failure of the supply, but simply from mismanagement of the work. The crystals were certainly less abundant at the last than in the earlier workings, but the lake still held and doubtless holds now an amount running to many millions of pounds, if it be not in truth practically inexhaustible.

Their abundunce was such, and the yield was so great, that within the period specified the lake had revolutionized the borax-trade of the United States; in fact, it had accomplished that work before the close of the year 1864. The annual importations since 1855, the earliest date at which the congressional reports enable us to trace them, had varied from $143,218 to $217,944. In 1864 they were suddenly reduced to $8,984, a result due entirely to the working of Borax Lake.

A statement of the manner in which the crude crystals were removed and utilized will bring to our notice the strange peculiarities of their nature, origin, and mode of crystallization.

The mud which constitutes the bottom of the lake is a smooth, even, plastic clay, of unknown depth. It has been bored through thirty feet without showing change in its structure. The upper por-

tion, for four and a half to five feet, holds unnumbered crystals; at that depth they suddenly and abruptly cease. Abundant explorations demonstrated that none were to be found any lower, and the daily working came to recognize the fact as established. The mud below that was saturated with the salts of soda, such as held by the water of the lake, but no distinct crystals existed.

The crystals of borax, in the upper portion, were removed by means of coffer-dams. Each dam consisted of a box, without top or bottom, four feet square and six feet deep, made of thin boiler-iron, suitably stiffened with surrounding bands of heavier iron. These dams, suspended above the water, between large pontoons or floats, were allowed to drop suddenly, whereupon their force of descent drove the sharp lower edge down through the soft mud and into that which was sufficiently firm and tenacious to resist the impact, and to render thus the iron walls of each a true coffer-dam, from which the entire contents could be easily removed.

The water was first pumped or bailed out, till it became too thick to flow easily, and the remaining mud was lifted in tubs, in true mining style, and thrown into large troughs, where, being subjected to constant agitation in streams of the lake-water, it was washed away, the borax being retained by its superior gravity.

No crystals were found until from twelve to fifteen inches in depth of the most fluid mud had passed away. The mud then began to feel "gritty," as the workmen expressed it, the "grit" consisting of multitudes of most exquisitely perfect minute crystals of borax. These crystals, like all those in the lake, were lying loose, detached from each other, attached to nothing by the base, and consequently perfect at both ends. It is not meant by this that every crystal was absolutely complete in every angle, but that they all had the tendency to the theoretical type, symmetrical at each end (a form which in artificial crystallization we scarcely ever reach, except by accident), and that many of them showed the type in full perfection, such as no model could excel or equal.

With every descending inch through the mud their size increased; the "grit" soon became "sand," in a few inches farther crystals were very manifest to the eye, and shortly a "layer" was reached. It is true that in some places no "layers" occurred, the crystals being scattered at random through the mud. But in most instances when from twenty-four to thirty inches of surface-mud had been removed, and the crystals had attained a length of one fourth to one half an inch, one or more "layers" would be found within the four feet square of the coffer-dam. In these "layers" the crystals were so closely packed as to have no mud intermingled with them; they were nearly as clean as though recently washed in clear water, lying closely stowed and loose, like pebbles on a beach. A "layer might be one to four inches thick and two feet, more or less, in length, surrounded on all sides by

mud which held only scattered crystals without any such richness as its enveloped pocket.

Going deeper, the crystals became constantly larger, though less numerous, as the mud grew more dense, until a stratum was reached which was designated "blue clay." In the mud immediately above the blue clay, crystals from one to two inches long were very common, though many of the smaller ones were still intermingled. Here a change in the crystals showed itself, full as well marked as the change in the bed in which they lay. The small crystals were not present; they had never been formed as in the mud above. Instead of them lay imbedded scattered crystals, few in number, but of great size, and having commonly a family look by which they could be recognized. Few of them were as small as two inches in length, and not unfrequently those weighing a pound each were obtained, being perhaps five to seven inches long, by two to four inches wide.

They lay imbedded in the clay, which was so firm that they could be picked out singly, each leaving the sharp mold which it had formed during its slow process of crystallization. They were all within a little more than a foot of the surface of the blue clay, many explorations showing that it was useless to seek for them at a greater depth.

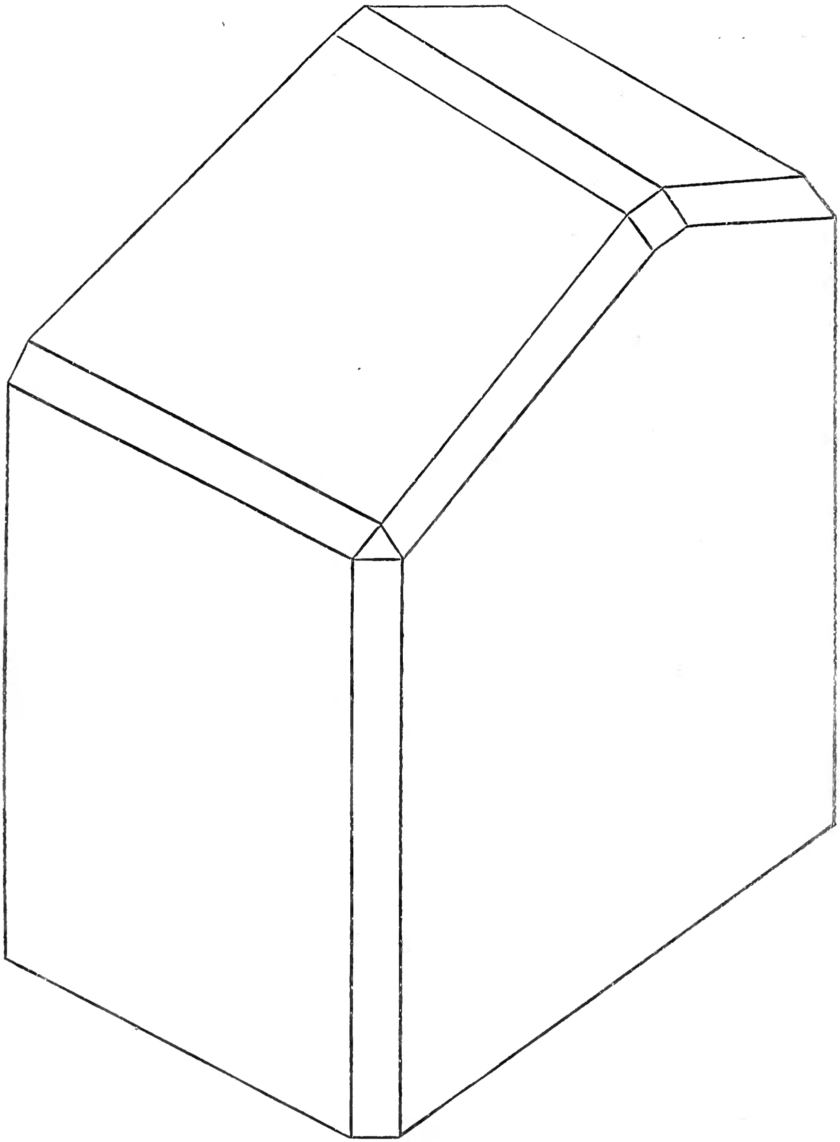
Of the abundance of the crystals within the portion of the lake occupied by them, a space of about forty acres, some idea may be formed from the fact that nine hundred pounds have been gathered from one dam, four feet square. And this by no means represents their full amount, as all the smaller crystals were washed back again into the lake in the process of their separation. At the same time it was remarkably true that the yield was very uneven. In what was known as "rich ground" barren spots constantly occurred, and often almost the entire yield of a dam came from one side or one corner, perhaps only a third or a fourth part of the full area.

The crystals thus obtained had a decidedly green color. The figure introduced is given for the purpose of conveying an idea of the size which the green crystals sometimes attained. It is not an exaggeration. I have seen many which weighed individually as much as the one here delineated. Their proportions were very erratic, but always conforming to the one type.

They were entirely free from the tenacious coating incident to the tincal of other localities; were readily and perfectly soluble in hot water, and in the process of refining by solution and recrystallization yielded their full weight of transparent borax of the finest quality, less merely the weight of the mud which had been mechanically entangled with them during their growth in a muddy menstruum. The green color disappeared in the refining, not being found either in the deposited mud or the new crystals.

We are prepared now to look at the origin of these salts as held in solution or in crystalline form. If, in a basin of water, more or less

shallow, containing a plastic soda-mud in the form of chloride and carbonate, deriving its carbonic acid from one source and its chlorine from another during its deposition, or, subsequently, fissures were opened



CRYSTAL OF NATIVE BORAX FROM BORAX LAKE, NATURAL SIZE.

in the subjacent strata, allowing the escape of a limited amount of jets of boracid acid from beneath in vapor, we should have all the conditions required to account for the formation of the borax in the midst of the two more loosely combined salts.

Thus far our way is plain. But whence came the enormous deposition of the green crystals of Borax Lake, their isolation and segregation in perfect crystallized integrity, and their continued preservation; while at the same time, in a solution almost identical in chemical composition, as we shall see, at Hachinhama, and in which often the proportion of borax to a given quantity of water becomes greater, no such crystals exist?

In most instances of salts crystallizing from a solution, the crystals attach themselves by a base to whatever material is adjacent, and when numerous they form a crystalline mass, from which the summits only of the crystals project—a crystal perfect at both extremities, and the sides not being common. And in Borax Lake itself, whenever the water has evaporated to such a degree in a dry season as to form a deposit from excess of strength, it has been an amorphous crust of carbonate, chloride, and borate, with no perfect crystals of either.

But the green crystals are isolated, and in thousands of instances are absolutely perfect, ends and sides. The large ones of the blue clay lie, as we have seen, each in its own mold. The smaller ones above lie often in layers, inches in thickness, hundreds of crystals heaped together as distinct from each other and as separate as pebbles on a beach.

Still, again, comes the strange fact that these crystals have been lying, how long we can not say, but almost certainly for very, very many years (for there is not the slightest evidence to lead us to believe that they are of recent formation), in a solution which makes no approach to saturation, and to whose influence as a solvent they seem totally indifferent.

The water of Borax Lake, when it has a depth in its main extent of five feet, which it often has for very many months and perhaps years in succession, holds in solution about half an ounce of borax to the gallon. During this interval, for four or five months of the summer season, its temperature is at no time lower than 55° to 60° Fahr. But water at that temperature dissolves a little over eight ounces of borax to the gallon. How, then, can the green crystals remain in such a liquid so long without being destroyed?

It may be supposed that the carbonate and chloride, in the complex mixture, render the hold of the borax so slight that, because of their presence, it is ready to separate. In reply to this suggestion comes the statement of the fact that when the same water is concentrated by evaporation to a specific gravity of 12° Beaumé, in which state it holds in solution six ounces of borax to the gallon, no tendency is manifest to the formation of even a single crystal.

Again, it has been suggested that, lying in a muddy menstruum, the movement of particles is so far arrested as to prevent diffusion, the stratum of water immediately surrounding each crystal becoming saturated and remaining unchanged. But this does not in the least

account for the commencement of crystallization, which, so far as we can judge, must have been in an exceedingly weak solution. Nor does it perhaps seem possible that such complete seclusion from ascending and descending currents could in any way be secured. The winter rains pour in quite fierce torrents of drainage-water from all sides, often rendering the entire lake decidedly turbid, and of course causing more or less of commotion in every part. And in addition to this is the diffusion of particles, caused by the changes of temperature throughout the year.

In whatever light, therefore, the question is viewed, it is not free from difficulties. And yet at the same time it is but right to recall the fact that these green crystals are in their nature tincal, though such tincal as has never been found elsewhere, and that the crystals of tincal are perhaps in other localities formed subject to the same conditions as here prevail.

We turn now to Hachinhama, the other locality mentioned, as affording the borax-supply of California. This is on the southern side of Clear Lake, about four miles west of Borax Lake, which it closely resembles in its features, though much smaller, being an oval lagoon about four hundred yards in length. We have, as there, a sheet of clear alkaline-water, with a bottom of soft, plastic mud. This mud has been bored to about the same depth as in the explorations at Borax Lake, without its lower limit being reached.

The evidences that the alkaline pool occupies the space of an extinct crater, are more manifest here than at Borax Lake, as the inclosing walls still remain, though abraded on their northern extremity, while on the south they rise abruptly to the great mountain-summit of Conoktai.

The water of Hachinhama holds in solution the salts of soda in the following proportions: Sodium carbonate, ·754; sodium chloride, ·083; sodium biborate, ·163. The mud throughout its entire depth is richly stored with the same salts, but without any development whatever of crystallization of any kind.

After the cessation of work at Borax Lake, in 1868, attention was turned to the resources of Hachinhama. Of course, the style of working must be totally different, for here was no borax ready formed, no green crystals needing simply solution and recrystallization. All that was available was a sheet of water, holding the salts above recorded. The problem, then, was to separate in purity the borax—the only one of sufficient value to be worth the effort—and leave the others.

Borax being the least soluble of the three salts, and at the same time much more soluble in hot water than in cold, it was argued that, were the water of Hachinhama sufficiently concentrated by boiling and then allowed to cool slowly, the borax would crystallize out, leaving the carbonate and chloride in solution.

This is correct in theory, and in laboratory practice the results

were entirely satisfactory, but in working large quantities the case was found very different. Concentrated to 20° B., a crop of crystals was deposited which were pure borax, but they were scarcely more than fifty per cent of the borax originally held by the lye thus formed. When, now, this mother-liquor was still further concentrated, no more pure borax separated, but a combined mass of borate and carbonate.

And here was manifested another feature. The amount of borax available depended very largely on the bulk of the solution in which it was allowed to cool. Very small quantities were of course useless in practical working, though the crop from them was satisfactory. Patiently continued trials showed that pans of two to three gallons gave economically the best results. But even here the borax clung so closely to the carbonate as to occasion much difficulty, until the plan was devised of crystallizing them together, and then washing away the carbonate by means of its greater solubility.

This was the plan adopted, and by its use about eighty per cent of the borax originally contained in the Hachinhama water, as pumped into the evaporating-pans, was secured. The extent of the works may be estimated from the fact that about 4,000 of the pans mentioned were in daily use.

But the unassisted lake-water was not long used. Hachinhama, from its shallowness, becomes nearly or quite dry at the close of each summer. As it dries away, the exposed mud is thickly covered with the salts deposited. These were carefully removed for use. The surface thus cleared of its salts began at once to renew its coating, the deposit being speedily replaced by capillary attraction from the stores beneath. In a week, or perhaps more, the surface was ready for sweeping again. The second crop was abundant, it was replaced by a third, and by others in succession, till the advent of the rains (never occurring in that climate till October, or perhaps November) put a stop to their formation.

This process was repeated each year during the occupation of Hachinhama, and, when the lake filled in turn with the winter rains, the alkaline-water bore the same degree of strength consecutively, showing that the stores of supply in the mud beneath gave no evidence of exhaustion.

The salts thus gathered were used by lixiviation to strengthen the lake-water in the evaporating-pans, and thus increase the yield of borax.

The work of refining the borax thus obtained differed in nothing from that employed with the green crystals of Borax Lake—hot solution and crystallization in lead-lined tanks. Hachinhama borax, as placed in the market, was of a grade of excellence never surpassed.

The works were conducted in this manner until the spring of 1872, when a change was introduced in consequence of the discovery that immense deposits of borates existed in Nevada. It was determined to

utilize the borate of lime, in the form of ulexite, for the conversion into borax of the carbonate of soda held in the water of Hachinhama.

The ulexite was brought by car-loads from the deserts east of the Sierra Nevada to San Francisco, and thence to Clear Lake, and a great increase in the borax yield of Hachinhama was the result. The process adopted was to saturate, with the ulexite, the boiling lye from the lixiviating tanks, before it had acquired sufficient strength to crystallize on cooling. A double decomposition was thus accomplished, resulting in a thick, milky-looking mixture which was an intensified solution of borax, rendered turbid by the insoluble carbonate of lime, this latter speedily settling and leaving the clear borax-liquor for concentration and crystallization.

Practically, however, this solution was never pure, for here came in again the same fact which had been demonstrated in the first workings at Hachinhama, that the bulk of the liquid in which the action took place had much to do with the chemical union accomplished. In laboratory experiments the work was perfect, and a boiling-heat of only a few minutes formed the full theoretical amount of borax demanded ; yet, when dealing with large quantities, this proved impracticable. Although violent boiling was long continued, even for hours, analysis of the lye showed that a certain proportion of the carbonate of soda still remained untouched by the boracic acid, and that, too, when the ulexite employed was in excess of the amount which careful analysis showed was sufficient to saturate the carbonate of soda present. And this excess was a necessity, and the daily working came to recognize it and to act accordingly, for, when the even theoretical quantity only was used, a much larger proportion of the soda remained untouched.

The operations at Hachinhama continued vigorously till 1874, by which time the enormous supply of borax brought into the market from Nevada had reduced the price to so low a point that further production became impossible. Hachinhama supplied all the American borax made from the cessation of work at Borax Lake in 1868 till 1873, and the two localities afforded between 1864 and 1874 all that was ever made in California. The yield of Hachinhama, during the last two years of its running, was something over 5,000 cases of 112 pounds each.

The immense stock crowding upon the market, which has reduced the price of borax to very nearly one fourth of its former rate, is commonly called "California borax," but that is a misnomer, originating in the fact that it has necessarily been shipped from San Francisco ; it is exclusively a product of Nevada. It is, in its look, so unlike the ordinary English borax, or that made at Hachinhama, that the contrast is very striking. Still it is practically the same, and has the same working value.

A glance at the map of the State of Nevada shows a large number

of dotted spots, individually of no great extent, scattered over the desert regions east of the Sierra Nevada. Most of them are without designation, but a few are marked "Soda Flat," "Salt Marsh," etc. They all have probably a common origin; they are places which long ago (how long we can not tell) were covered with water, since removed by solar evaporation. Each consists of an extent of entirely flat surface of dried mud, sometimes absolutely bare, sometimes covered with saline deposits. It had been known for years that these deposits were both what is there universally called "alkali" (carbonate of soda) and salt. But it was not until 1871 that much attention was drawn to the fact that several of them contained also deposits of borates, though published mention had been made some time earlier that these existed there.

The number of these "marshes," which are marked by borate deposits, it is impossible to state, as so large an extent of that arid region remains as yet very imperfectly known. A sketch of one, however, gives the characteristics of all.

One of the largest is known as the "Columbus Marsh." It is situated in Esmeralda County, about two hundred and fifty miles nearly due east from San Francisco, and about one hundred and sixty miles south of Wadsworth, on the Central Pacific Railroad. The portion last abandoned by the water, and now covered by saline deposits, extends about ten miles from east to west, and three from north to south, with an extension on the south into Fish Lake Valley, forming an arm fifteen miles long by one to three miles wide. Not all parts of this extent are equally rich in salines, neither is the character of the deposits the same at different parts, though it must have formerly been covered with one sheet of water, of presumably a uniform quality or nearly so.

A space of several hundred acres in one part, for instance, is covered with a crust of chloride and carbonate of soda, through which the foot breaks at every step; but the black mud beneath is filled to the depth of six to twelve inches with borate of lime aggregated in nodules, which, when broken open, show a beautiful pearly-white mass of satiny luster. These are the ulexite, and are commonly called "cotton-bolls." They can be picked out by hand like the kernel of a nut, separating clean and clear.

Immediately adjoining the ground thus rich in ulexite is a wide stretch barren of everything, except a little chloride and carbonate. Just beyond this come five or six hundred acres, thickly covered with borate of soda, so little contaminated with sand or anything else as to crystallize out, by simple solution, eighty per cent of its weight in pure borax. Over vast extents of this surface I have seen the crude borax in its granular, semi-crystalline form lying from fifteen to twenty-four inches in depth, while, at the distance of a quarter to half a mile, the borate of lime was in similar abundance. The supply of borax

thus indicated is manifestly sufficient to fill all demands, far into the future years, and this refers only to that which is now on the surface; while the experience gained at Hachinhama seems to show quite conclusively that, were all the present store removed, its place would be refilled with a new crop drawn from the inexhaustible resources beneath.

To explain the manner in which these separate deposits have been formed is not easy, though in relation to the two borates the following suggestions may possibly be of some avail: If in a broad, shallow, mud-bottomed lagoon, the sodium of which has already formed its combinations with carbonic acid and chlorine, we imagine the process of evaporation to continue until instead of water there remains merely a muddy mass, so far viscid as to be unable to flow from one point to another, and that into this mass boracic acid is forced from beneath in jets, here and there, only in limited areas, and not extending beyond them, and if we imagine, still further, that the supply of boron is not sufficient to displace all the carbon and chlorine, we should have carbonate and chloride existing, intermingled with borate of soda, precisely as we in fact find them, and with a lime-mud we would have the ulexite.

This may perhaps answer for the borates, but a much greater difficulty is encountered when we propose to ourselves the question how the carbonate and the chloride crystallized separately. Over the chief extent they are blended, as they would be left by the evaporation of a lake which held them both in solution. Yet it is also true that, here and there, in areas separated from each other by no elevations whatever, and which have evidently never been separated, but which must have been parts of the same lake, vast beds of pure salt occur; while, perhaps, a quarter or half a mile away, carbonate of soda is lying in equally great quantity. How can these masses have been thus placed? Their bulk demonstrates that in each case quite a considerable depth of solution, even in its most concentrated form, was absolutely necessary. They could not have existed in such juxtaposition and have retained their chemical integrity.

Could the deposits have been formed at different times? There is nothing to indicate it, nor is the difficulty made less by answering this question in the affirmative. The chloride, in a blended solution, would of course be the last to crystallize, yet there is nothing to cause us to believe that over the carbonate-beds a mass of salt was once formed and subsequently removed. Neither can the two salts be crystallized in bulk, from a united solution, by any means with which we are at present acquainted, and left in the state of separate purity, in which countless thousands of tons are now lying on the deserts of Nevada.

The question is as difficult as the one why the mud of Borax Lake is filled with the green crystals, while that of Hachinhama has none.

The points concerning the combinations and the crystallizations in the Californian localities, and in those also of Nevada, I can vouch for personally. The facts are as set forth. I have mentioned nothing which I have not myself seen. The questions which are left without answer are certainly worth investigation.

PROTOPLASM.

By FRANCES EMILY WHITE, M. D.*

AT the recent International Medical Congress, held in London, upon which the attention and enthusiastic interest of the whole medical world were for the time being centered, Professor Huxley, in an address made to that assembly, used the term "medicine" to include "the great body of theoretical and practical knowledge which has been accumulated by the labors of some eighty generations"—that is, during the entire period since the dawn of scientific thought in Europe. In justification of this broad application of the term, he says, "It is so difficult to think of medicine otherwise than as something which is necessarily connected with curative treatment, that we are apt to forget that there must be and is such a thing as a pure science of medicine—a pathology which has no more necessary subservience to practical ends than has zoölogy or botany." In other words, there is a science of disease and an art of healing, both of which are included in the term "medicine," and, as all art is applied science, it is easy to see where the study of the "healing art" should begin.

Pathology is abnormal physiology, or, more broadly, biology, the science of living matter; living matter being recognized by its innate tendency to undergo certain changes of form and to manifest certain physiological phenomena which are universally recognized as constituting organization and life. When these changes of structure or of function become injurious to the organism, or cease to promote its general well-being, they are pathological, but the line of separation is not a distinct one; it is impossible to say with exactness where physiology ends and pathology begins.

It is evident, then, that the science of disease is a branch of the general science of life; and the distinguished lecturer, in making so wide an application of the term "medicine," no doubt intended to assert that the science of biology rests upon the broad foundation of the general physical sciences. The study of medicine, then, consists primarily in the study of biology, including those abnormalities of

* Address delivered at the opening of the Thirty-second Annual Session of the Woman's Medical College of Pennsylvania.

structure and perturbations of function to which living matter is liable; and, secondarily, medicine deals with the applications of the knowledge thus acquired for the checking of these perturbations and the renewal of normal structures—in other words, for the relief of suffering and the restoration and preservation of health.

The field of medicine is, then, a large one. As already intimated, some knowledge of the various natural sciences is essential to its successful study; not only by reason of the fact that living matter is subject to the same chemical and physical laws as non-living matter, but also because of the intimacy of its relations to its physical environment, and of the constancy of the reactions between every organism and its environment.

As a general introduction to the course of medical study now opened in this college, it has therefore seemed appropriate to devote an hour to a brief biography of *Protoplasm*, the universal life-substance from which all organisms, whether vegetable or animal, originate, and modifications of which constitute even the most complex tissues of the highest animal forms.

Though so universally diffused, though the autobiography of protoplasm has been written in the life of every plant and animal since creation's dawn, it is still a hidden story in some of its earlier chapters. Perhaps it is the very simplicity of its origin that balks us: we would fain invoke some supernatural explanation of the growth-force and the capacity for development which belong to this substance, as distinct from non-living matter, forgetting that all natural forces are equally elusive and obscure. Why do certain kinds of matter always crystallize in certain fixed and characteristic forms? Why, on the other hand, is protoplasm formless, but capable of endless development and change?

There are certain chemical and physical differences between crystallizable and non-crystallizable substances which, if fully understood, would no doubt furnish an answer to this question.

Protoplasm, a non-crystallizable substance, is both physically and chemically of a highly complex composition not determined with exactness, but known to consist mainly of hydrogen, oxygen, nitrogen, and carbon, variously combined in such proportions as to produce representatives of three classes of chemical substances—the albuminoids, the starches, and the fats—the albuminous constituents largely predominating in native undifferentiated protoplasm.

With these compounds is associated a considerable though varying proportion of water, as well as smaller quantities of saline and other crystalline substances.

Of the molecular structure of living, active protoplasm, nothing definite is known; it is, however, probable that the albuminoid matter of its massive molecule is associated with a complex fat and with some form of starch; while the water and the salts may be loosely combined

either physically mingled or perhaps weakly held together by the feeble chemical affinities which belong to all massive molecules. This constitutes a slime-like mass which, like all chemical compounds, exhibits certain characteristic reactions by which it is clearly distinguishable from certain substances, and known to be closely allied to certain others.

Protoplasm has the power of absorbing water in varying quantities, so that it is sometimes soft and nearly fluid, and again hard and leathery, though ordinarily of a medium consistence and density best described by the term "slime-like" already employed. It is then a glairy, tenacious, semi-fluid substance, transparent, and generally colorless; and if not quite the homogeneous, structureless matter which it was long supposed to be, there is at least an entire absence of differentiation of structure quite comparable to the observed absence of localization of function. When it acts it acts *en masse* or indifferently, sometimes in one portion, sometimes in another, of its substance, for the production of its simple movements and for the bringing about of its protean forms. Now all mouth, and anon all stomach, at times all feet, and again all lungs, it fulfills Dryden's famous description, "Everything by starts, and nothing long," save that it is ever and always *protoplasm.*

Like other albuminous substances, it is coagulable by heat, by alcohol, and by mineral acids, and is similarly stained by iodine and by nitric acid. Living protoplasm possesses also certain fundamental properties by which it may be distinguished from dead protoplasm. Prominent among these properties, grouped under the single term "vital," may be mentioned first, excitability, or, as it is more commonly called, "*irritability,*" by which is meant the power of responding to a stimulus. An amœba suddenly brought in contact with some foreign body responds to the stimulus so received by certain characteristic movements.

The movements of protoplasm, however, can not always be thus traced to some external exciting cause. Watching a specimen beneath the microscope, portions of the mass may be seen to creep, or rather to flow, slowly away in fine threads uniting with other threads from different parts of the same mass, thus forming an irregular net-work. Or perhaps it thrusts out temporary feet indifferently from any part of its surface by means of which it creeps slowly about, and it draws them in again, returning to the somewhat globular shape which appears to belong to its quiescent state. These movements are spontaneous; that is, they originate in the mass and result from the essential constitution of this kind of matter; therefore protoplasm is described as "*automatic*" or self-acting, and even as having a will of its own.

The internal changes which bring about these movements are believed to be identical with those which occur in muscle-tissue under stimulation, producing the change of form in muscle-fiber known as

contraction; hence protoplasm may be said to be "*contractile*," and this is another of its so-called vital properties.

Protoplasm also feeds upon nutritive material brought into contact with its surface. This it does by flowing around the substance, whatever it may be, which serves for its food, thus inclosing it in a temporary stomach improvised anew for each occasion, and becoming gradually obliterated as the new material slowly dissolves and is absorbed, mingling and chemically combining with the already existing protoplasm, and thenceforth forming a part of its substance. In other words, certain kinds of dead matter called food are assimilated, converted into living protoplasm by those processes of absorption and chemical union which constitute nutrition in all living things. Hence, protoplasm is "*assimilative*," and this is another of its vital properties. Side by side with this process of taking in new material and converting it into its own substance, there is also another process going on—that of rejection of old, broken-down, effete matter which has not only become useless to the living protoplasm, but would be injurious if retained.

The life of protoplasm is thus seen to consist in a double series of chemical changes, by one of which its substance is constantly renewed and built up; by the other, it as constantly breaks down, the products of decomposition being gradually rejected from the living, ever-fluctuating mass, which thus becomes the theatre, the arena, of life.

What is the outcome of this constant play of chemical and physical forces—this incessant interchange of matter between the mass of protoplasm and its environment? In other words, what is the meaning of the life thus manifested? Its significance is this: *The production and manifestation of new and higher kinds of force than any belonging to inanimate, inorganic matter.*

In the life of protoplasm we behold the dawning of voluntary motion—of those spontaneous movements especially characteristic of animals (though shown to a slight extent by plants as well), and exhibited in the highest degree by man in the thousand muscular adaptations displayed in his complex mechanism.

But the doctrine of the correlation of forces formulates the fact that the amount of force in the universe of matter is constant and unvarying; that, as matter is indestructible, so the forces which it manifests are persistent—never increasing, never diminishing. Whence, then, comes this new and higher kind of force called spontaneous motion? It is a law of physics that, as elemental molecules aggregate to form those which are more complex and massive, the force previously manifested by the simpler molecules becomes potential or latent, as it was formerly expressed; and that in the breaking down of these more complex molecules, in their return to their former simple state, this hidden force springs into activity again, not necessarily reappearing, however, as the same kind of force; there is not only a storing

up of energy, but a transformation, a remolding of it in other and, in the case under consideration, higher kinds. As the wide and rapid vibrations which constitute the expansive power of steam are made, by means of suitable mechanical appliances, to disappear in condensation and to reappear as locomotion, so the potential forces locked up in the molecules of protoplasm appear in the breaking down, the decomposition, of these molecules as spontaneous movements of some portions of the mass.

The energy expended in the movements of protoplasm is supplied through the chemical changes going on in its substance, by the breaking down of compounds possessing much latent energy into more simple ones containing less such energy.

These downward chemical changes are mainly processes of oxidation, one of the chief products of oxidation being carbonic-acid gas. Now, the taking in of oxygen and the giving out of carbonic acid together constitute respiration; hence protoplasm is "*respiratory*"—another of its vital properties. It breathes, as the fish does, by absorption of oxygen from its surrounding medium; but it breathes at the entire surface of its mass instead of at special parts of its surface, as in the fish. This is true of vegetable as well as animal protoplasm, the two being indeed regarded, in all essential points, as identical.

Protoplasm is also "*reproductive.*" Haeckel, in his history of the discovery of the monera, which consist of little globules of simple protoplasm, describes their mode of reproduction as follows: "The little creature divides into two halves, and each of these goes on living like the original one."

But there is a form of living protoplasm even more simple, if possible, than the moneron of Professor Haeckel—the *Myxomycetæ*—of which a very good description may be found in the inaugural address of Professor Allman, President of the British Association, in 1879, published in the October number of "The Popular Science Monthly" of that year. These organisms consist, during the greater part of their lives, of simple protoplasm. They may be found in moist places growing on decaying leaves, rotten wood, etc., etc., over which they spread in the form of a net-work, exhibiting amœboid movements, appearing to be sensitive to the light, and giving other evidences of life.

But we may find a specimen of protoplasm even nearer home than this. Prick your own fingers, if you choose; withdraw a drop of living blood from the wound, and, having properly diluted it, place it under your own microscope for observation. Scattered among the numerous small bodies which give to the blood its brilliant crimson hue, may be seen a few somewhat larger colorless ones—the leucocytes or white cells.

These microscopic bodies consist mainly of simple, undifferentiated protoplasm. They differ from the monera (first found by Haeckel floating on the surface of the Mediterranean Sea) in being nucleated;

that is, they contain a central kernel, the nucleus, which is more dense than the surrounding protoplasm, and of a slightly different chemical composition. These bodies, which circulate among the tissues with the blood forming a part of it, manifest independent movements, thrusting out and drawing in portions of their mass in true amœboid fashion; they devour solid particles of matter which come in their way—their smaller comrades, the red corpuscles, not always escaping their voracity. This they do by flowing around and inclosing them, as already described. They have also been observed by Klein to multiply by division, like the monera. The white blood-corpuscle, identical, apparently, with the amœba, which may be found in the standing water of pools attached to the surface of leaves, and in many other similar situations, is a true cell—the morphological unit from which all organisms, whether low or high, originate, and by whose multiplication, development, and differentiation, all the tissues of their bodies are produced.

The history of the growth and development of every animal—whether moner, mollusk, or man—is a history of cell-multiplication and cell-differentiation; and the most highly endowed individual of them all possesses no property, no faculty, no power, which is not at last foreshadowed in the formless, structureless, protoplasmic cell from which they are all alike derived. Is the nervous tissue of man in the highest degree irritable and automatic—that is, sensitive and self-acting? So is protoplasm, though in an almost infinitely less degree. Is muscular tissue eminently contractile, serving for the production of the varied and complicated movements of all parts of the body? Protoplasm is also capable of slight spontaneous motions of its entire mass. Are the various glands of the body actively secretory and excretory? So is protoplasm within the narrow limits of its chemical necessities. Equally, also, with the highest tissues and organisms, it reproduces its kind.

The complex body of any one of the higher animals may, then, be considered as consisting of certain tissues, each of which has not only been derived from protoplasm but each of which corresponds, in its perfected function, to some one of the fundamental properties of protoplasm, to the special manifestation of which it is devoted for the benefit of the organism as a whole, on the important principle first spoken of by Milne-Edwards as the physiological division of labor. Division of labor among the tissues, however, as among the members of a community, has its limits. While every tissue has some leading quality, some special function, developed to the highest degree in the interests of the organism as a whole (contraction in muscle-tissue, secretion in gland-tissue, and so on), yet each tissue retains in its own private interests, as it were, vestiges of all the other protoplasmic properties belonging to their common ancestor. Hence, all the tissues are assimilative to the extent of keeping up their own nutrition; all are

to some degree irritable, all are capable of reproduction of their own kind of cells, and so on.

Thus, from the beginning of his career, as a microscopic speck of living matter, to its close, although he figures as the most highly endowed and transcendent of beings, man, biologically considered, is *protoplasm, protoplasm, only protoplasm ;* and, whatever his perfections, regarded as a member of the animal series, he has the high privilege of knowing if not of feeling himself the brother of all living things. With Job, he may say unto the worm, "Thou art my mother and my sister." "Oh, why should the spirit of mortal be proud?"

"What, then, *is* protoplasm?" we are inclined to ask, almost at the close of our attempt at a description.

Professor Huxley has called it "the physical basis of life"—an expression which has become classic in the scientific world—while life, in its turn, is defined as a property, or congeries of properties, of protoplasm. Pflüger has naïvely said, "Albumen lives"—that is, becomes protoplasm—"when it begins to take in oxygen"; and Foster, with equal simplicity, remarks, "The whole secret of life may almost be said to be wrapped up in the occult properties of certain nitrogen compounds."

Lewes, in his own graphic style, has said, "The organism and its environment are the two factors, of which *life* is the product."

Protoplasm is the agent by which the energy of non-living matter is converted into that of living matter—the sacred fire which is never permitted to go out, but perpetually glows on the altar of Nature, fed by the vestal forces of the environment, and burning ever higher and higher through those twin influences, heredity and the survival of the fittest.

This true "vital spark" is not only transmitted from generation to generation in the entire animal world, each reproducing its own kind, but it has been handed on, through vast geological ages, from branch to branch of the animal tree, since that far-off period when the "dawn-animal" first left its imprint in the hardening mud of its slimy bed at the bottom of a vast ocean whose waters were still under the influence of the earth's heated interior, when this ocean was overhung by a sky dark with clouds so dense that day and night were scarcely distinguishable, and shutting in an atmosphere heavy with carbonic-acid gas.

The relations observed between the fossil animals thus far discovered, the existing animal series, and the embryonic forms of all animals at the various stages of development of their respective embryos, are most significant. The earliest, oldest known fossil (the *Eozoön Canadense*, or "dawn-animal," the genuineness of which, though denied by some, is more than probable) belongs to the same class of organisms as the moneron and the amœba of to-day, which stand at the bottom of the scale of animal life; and the geological ladder in its ascent bears upon its successive rounds fossils which correspond, with

more or less exactness, to the ascending series of now living forms; showing, however, in addition to these, many connecting links between existing classes, which, in the progress of time and development, have diverged widely from each other; while the modern science of embryology as clearly shows that the development of the human being—beginning in a formless, structureless, microscopic speck of protoplasm, comparable in all appreciable respects to the "dawn-animal" of the Palæozoic period, and to the moneron and amœba of to-day—consists in the ascent, step by step, with a good degree of exactness, both of the geological ladder and of the trunk of the animal tree whose branches represent all existing forms of animal life, whose roots are deeply imbedded in the inorganic crust of the earth, and at whose apex appears the *genus homo*—the crown and consummate flower of organic development. In other words, the individual development of every human embryon is a brief *résumé* (in which, it is true, some of the chapters are suppressed and others greatly condensed) of the history of the development of animal life on the globe, from its infancy to the present day.

In 1862 Professor Graham pointed out the importance of the two states of matter, described by him as crystalloid and colloid—crystal-like and jelly-like. He says: "The colloidal state is, in fact, a dynamical state of matter; the colloid possesses energy, and may be regarded as the primary source of the forces appearing in the phenomena of vitality."

Although certain colloids have a very simple chemical composition (as silica, for example, which, ordinarily crystalloid, is capable of existing in a colloidal state), the molecular constitution of the colloids in general is undoubtedly highly complex. The molecule of albumen (a typical colloid closely resembling protoplasm), while it consists of but six different chemical elements, is estimated as containing several hundred atoms of these elements, which thus render the molecule an extremely massive one.

Now this massiveness of its molecules confers upon protoplasm a certain mechanical stability favorable to the preservation of organic forms; at the same time endowing it with the chemical instability essential for the constant exchanges of material which constitute nutrition and are characteristic of all living matter.

These massive molecules are also reservoirs of vast amounts of energy of the kind long known as potential—a term which, though likely to vanish, not into thin air but into the thinner ether, is nevertheless a very convenient one. This potential energy, stored up during the slow processes of plant-life and appropriated by animals in the form of food, is liberated or manifested as actual energy in the decomposition of their tissues—that is, in the gradual breaking down of tissue-cells, by means of which the animal functions are performed, and carbonic acid, urea, and other excretory compounds are produced.

But a large part of the tissues which make up the bodies of adult animals have, in a great measure, lost their resemblance to the protoplasm from which they were derived, through an extreme development which has resulted in tissues quite unlike each other—some of them, as the bones, for example, evidently serving a purely mechanical purpose in the body; and it may be said that a comparatively small proportion of the tissues of the body are, strictly speaking, living. Professor Beale classifies all the material of the tissues, and even of the ultimate cells from which the tissues are derived, under two heads, as *formative* and *formed*—that is, matter which has the power of producing new matter like itself out of pabulum or food, and that which has no such power, but which has been produced by the former. He considers that a muscle-fiber is not, like the protoplasm which produced it, living; and that the nerve-fiber also consists of formed material of which protoplasm is the builder.

In accordance with this view, only the lowest—that is, the nutritive—processes can be regarded as truly *vital*. The higher functions performed by the perfected tissues—the bones, the muscles, and the entire system of nerve-fibers and nerve-centers, including the brain—are mechanical rather than vital; the character of the function in each case depending on the character of the mechanism, i. e., on the particular relations of the parts concerned.

Muscle-tissue, for example, has but a single and simple physiological property, the power of change of form called contraction, and even this is a function of formed material rather than of living matter; but, through the mechanical relations of bones and tendons, of joints and ligaments, of associated and opposing individual muscular bundles, all the complicated and varied movements of the body are brought about.

The action of muscle is one and the same, whether it be expended in the grosser movements of locomotion, in the finer manipulations of the skilled artisan and the musician, or in the still more delicate adjustments of the vocal cords, by means of which the exquisite modulations, almost infinite in variety, of the voice of a Patti or a Campanini are produced.

These various adjustments are evidently mechanical in their nature. The so-called *vital* processes — processes identical with those taking place in the simplest animal that lives, and in the very grass beneath our feet, perform a comparatively humble part in the production of the vast results. The vital processes are concerned in the building up of the tissues and organs produced by and from protoplasm out of the food supplied to it; and the chemical changes involved in the breaking down of the tissues furnish the initial force in each case; but the actual forces manifested are due to transformations of this initial force brought about by the complicated mechanism which this force serves to set in operation.

The powers and possibilities of protoplasm may be crudely compared to those of steam, the expansive property of which may be observed in a simple apparatus for the grinding of coffee, for example, or in the operations of a magnificent Corliss engine, by which all the complicated machinery of an entire Exposition may be set in motion. The steam has precisely the same properties in the two cases, but the resulting forces differ in proportion to the complexity and multiplicity of the relations of the parts of which the different mechanisms are respectively composed.

In the study of the highly complex mechanism, the human body—which constitutes the study of medicine—all the powers and properties of matter must be duly considered and taken into account, for all are concerned in the production of its forces and in the performance of its functions; not one is violated or turned out of its natural course, but all combine in a harmony more complete than is manifested by any other known combination of materials and forces. Heterogeneousness the most extreme, complexity the most intricate, actions and reactions the most delicately balanced, all unite, in the play of the forces of the body, in the production and manifestation of its varied powers.

The study of science in any of its numerous departments is intrinsically elevating and ennobling if it be pursued in the true scientific spirit, viz., in the desire and search for truth for truth's own sake; and, while the pursuit of medicine has its practical side in preparing its votaries for the service of suffering and sick humanity—perchance for making the blind to see, the deaf to hear, and the lame to walk—it also broadens and enriches their own individual characters and lives, since it leads them into the green pastures by the still waters of the eternal truths of nature, at the same time bringing them into the still higher experiences of sympathy and charity toward all mankind.

THE MECHANICS OF INTERMITTENT SPRINGS.

By Dr. OTTO WALTERHÖFER.

THE springs called thermal springs are found in all latitudes, at various elevations above the sea, and in most of the geological formations. The word *thermal* does not, however, denote a spring of any particular degree of temperature, and is far from signifying that the springs to which it is applied are all equally warm; for any spring is thermal, the water of which is warmer than the mean annual temperature of the place where it occurs. In the equatorial regions, where the mean annual temperature is about 80°, a thermal spring should have a temperature of about 85°, while in the northern parts of the

earth, as, for example, at Yakutsk, in Siberia, where the year's temperature does not exceed 13°, it need be only a little above that. The waters of thermal springs maintain an equable temperature, and must therefore come out of depths in the earth at which the variations in the temperature of the air exert no influence. According to Boussingault, this depth in the tropics is only a little more than one or two feet, but between 48° and 52° of north latitude it is between sixty-six and ninety-three feet below the surface. Besides the springs that are called thermal, many springs are found the temperature of which exceeds the highest mean temperature of the year, and are called warm springs. Examples are the spring at Carlsbad, 167° ; that of Wiesbaden, 158° ; those of Baden-Baden, 154° to 111°, etc. The depth from which the waters come may be approximately calculated by the rule that the temperature increases one degree for every ninety feet below the surface. Hence the water of the bubbling spring at Carlsbad is supposed to come from a depth of seven thousand three hundred feet.

A third class of springs, the boiling springs, geysers, or hot springs, whose temperature is near the boiling-point of water, are peculiar in respect to the places where they appear. They are found only in volcanic regions ; are numerous in Iceland, where there are more than a hundred of them ; on the North Island of New Zealand, where they are most abundant in the neighborhood of the Roto Mahana, or Hot Lake ; and near the Yellowstone Lake, the Fire-hole and the Madison Rivers, in the region of the Wind River Mountains, in the United States, where some eight hundred of them are grouped within a certain well-defined area.

Among the hot springs, those which are intermittent, or the flow of which is uneven, are regarded with particular interest. Their waters are of a crystal clearness, with a slight tinge of green, and contain in solution considerable quantities of silicic acid, which frequently is deposited, in consequence of the evaporation of the water or the lowering of its temperature, as sinter. The most thorough investigations of the phenomena of intermittent springs have been made at the great geyser at the foot of the Bjärnafell in Iceland. Sartorius von Waltershausen,* Descloiseaux, † and Bunsen, ‡ have made extensive observations upon them, from the results of which, and of their own observations, Mackenzie, Bunsen, and, more recently, O. Lang, have formed theories respecting the mechanical causes of the intermittent flow.

The Great Geyser is situated at a height of one hundred and ten metres (three hundred and fifty-seven feet) above the sea. The part accessible to observation consists of a straight cylinder, R, lined with siliceous sinter, S, Fig. 1, about three metres (or ten feet) in diameter,

* "Physisch-geographische Skizze von Island," 1847.

† "Comptes Rendus," tome xxiii, 1846.

‡ "Annalen der Chemie und Pharmacie," Bd. lxii.

and twenty-three and a half metres (seventy-six and a half feet) deep, which widens out above into a tunnel-shaped basin, B, from two to three metres (six and a half to ten feet) deep, and seventeen to twenty metres (fifty-five to sixty and one half feet) in horizontal extent. The walls of the basin are formed of a cone of siliceous sinter, S, from six to nine metres (twenty to thirty feet) high, and about sixty-five metres (more than two hundred feet) broad. The water of the geyser is crystal-clear, with a greenish tint, and flows, except immediately after an eruption, steadily over the rim of the basin. A double motion may be perceived in the column of water inside of the cylinder. A hot stream ascends from the bottom in the axis of the cylinder, while the cooler water descends by the sides, but only to about half-way down, for it there unites with the rising hot current and ascends again to the surface. The temperature of the water is 179° at the surface of the basin; rises at the bottom of the basin to 192°, and rises in the bottom of the cylinder to 251° and 260°. The peculiarity of the intermittent streams consists in the fact that their waters mixed with steam are forcibly thrown up in huge jets at longer or shorter intervals. At the Great Geyser, jets of steam, accompanied by detonations raising the water to the height of about ten feet, appear in different parts of the basin at intervals of from one and a half to two hours. At intervals of from twenty-four to thirty hours, a column of water, mixed with steam, rises over the whole extent of the cylinder and the basin, with a sound as of distant thunder, to a height of from twenty-five to thirty metres (eighty to ninety-three feet), and scatters clouds of spray. After an eruption of this kind, the duration of which is about ten minutes, the basin and cylinder are empty; they are gradually filled up again in the course of from four to six hours, after which the processes described above are repeated. The loss of water occasioned by the eruption and overflow is made up for by side-streams, a part of which, W, being near the surface, probably bring in cold water; others, W′, entering at the bottom, water of a higher temperature than the boiling-point.

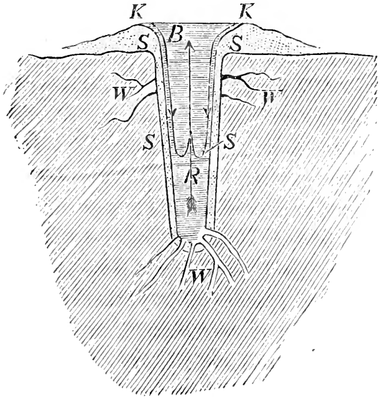


Fig. 1.

The following theories have been advanced in explanation of the periodical eruptions of the Great Geyser, and of the phenomena of intermittent springs generally:

According to Mackenzie's theory, a hollow space, *b*, Fig. 2, exists in the interior of the earth wherever an intermittent spring occurs,

the walls of which are formed of thick stone, free from penetrating clefts. Water-ways entering it from above and from the sides bring in cool waters; while other streams bring up from below water heated to above the boiling-point, or steam from the volcanic foci. The inferior conducting power of the rock-masses, inclosing the chamber

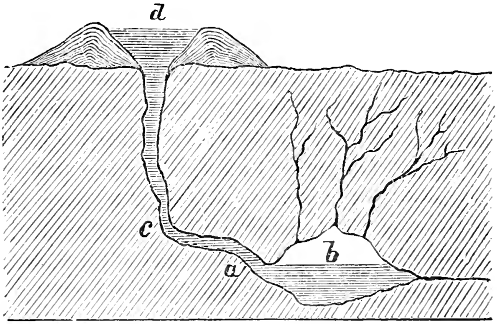


FIG. 2.—MACKENZIE'S THEORY OF ERUPTION.

and the stream-channels, prevents any material diminution of the temperature of the steam and the water, so that the chamber, *b*, becomes filled with hot water and steam. By virtue of its levity, the latter collects in the upper part of the chamber, while the water covers the bottom, and at the same time, as it is added to by the constant inflow from the canals which enter the chamber, *b*, rises and shuts up the tube at *a*. The steam is thus deprived of an outlet, and, since it is continually compressed into a smaller space by the constantly increasing mass of water, is added to by the entrance of new steam, and is heated to a higher temperature by the heat brought in with the hot water that keeps flowing in; it on its side exercises upon the surface of the water in the chamber a pressure that, increasing every moment, gradually raises the water in the tube, *c*, and causes an overflow over the rim of the basin, *d*. Finally, the pressure of the inclosed steam becomes so powerful as to overcome the absolute weight of the mass of water in the tube, *c*, and throw it up strongly and suddenly in fountain-like spouts. After the steam in *b* has relieved itself, and the pressure on the water has thereby been diminished, *a* becomes again closed up by the rushing back of the water from the tube and the flow of water from the chamber, and the conditions requisite to another eruption are produced. The temperature of the water in the chamber and in the tube rises continually between one eruption and another, and reaches in many places the degree at which steam is formed. This is the case in the lower part of the tube at *a*, where, the water nearer the chamber having a higher temperature than in other parts of *c*, the steam rises in *c* and causes the bubblings which appear in the basin at intervals of from one and a half to two hours.

This theory, which supposes a subterranean cavity acting as a kind

of steam-boiler, has now very few adherents, since Bunsen has given an explanation of the phenomenon that makes the supposition of a cavity in the interior of the earth unnecessary.

Bunsen gave his sagacious explanation of the periodical eruptions of the Great Geyser after observations and researches which he himself undertook in the year 1846. He found that the temperature in the geyser-tube, R, Fig. 1, is in a state of continuous increase between one eruption and another. Thus, if the whole column of water, R, is divided into layers of a specified thickness, one of these layers, for example, at a certain depth below the surface would show immediately after an eruption a temperature of 187°, which would rise after an interval to 188°, and then to 189°, etc. The more deeply situated layers would have a higher temperature at first, which would increase in the same manner. In no layer, however, would the temperature at which water is changed into steam be indicated before an eruption. The passage of water into steam—that is, its boiling—does not take place under all circumstances at 212°, but only when the pressure on its surface is equal to the weight of one atmosphere, or fifteen pounds to the square inch. If the surface in question is exposed to a lower or a higher pressure than this, water will boil at a correspondingly lower or higher temperature. Thus the boiling-point is depressed as we ascend mountains and enter regions where the pressure of the superincumbent atmosphere is less than fifteen pounds to the square inch. Conditions also exist in nature in which the boiling-point is raised to more than 212°, and may be found, for example, in the intermittent springs. To return to the tube R in the Great Geyser (Fig. 1), the water in which we have divided into a number of horizontal layers: a greater weight is put upon each successive layer in the descending series, since each one has to bear the weight of all the layers above it in addition to that of the atmosphere. Water, the temperature of which exceeds 212°, is called superheated. It has the property of being convertible instantly into steam as soon as the weight laid upon it is removed. Bunsen turned this physical behavior of water to the explanation of the eruptions of the Great Geyser. The water brought up in the streams (W′, Fig. 1) is in a superheated condition on account of the depth from which it comes and the pressure to which it is exposed. It is not, however, converted into steam on reaching R, because that is prevented by the weight of the column of water above. The layers of water above it are, however, heated by convection from it, so that they become specifically lighter, and originate the axial current toward the surface. As soon as it reaches the surface, the water is cooled by radiation, and a part of it falls back in the shape of the downward currents along the sides of the tube, causing a depression of temperature, and a corresponding delay in the formation of steam. But these currents are weak, their water is gradually becoming warmer as it gets farther from the surface, so that they only reach about the middle

of the tube R, and fail to prevent the temperature of the whole water-column from finally rising under the influence of the constant flow of superheated water from the streams, W′. The strata of water in the middle of the tube finally reach the temperature of the boiling-point at that depth. This water is then converted into steam, and thereby the pressure upon the lower strata is diminished. Then the strata of water still deeper in the tube are also converted into steam, and this throws the masses of water above it energetically out of the geyser-tube. The water being cooled somewhat in the air, a part of it falls back in the tube, and, producing a reduction of temperature, causes a short interruption of the formation of steam, but that is resumed again as the superheated water flows in, and continues till the whole column has been so reduced in temperature, by the water that falls back, that the liquid strata no longer reach the boiling-point corresponding with the pressure upon them, and the eruption ceases.

According to the theory of Lang, the Great Geyser occupies a space in the interior of the earth in shape somewhat like Fig. 3. The tube

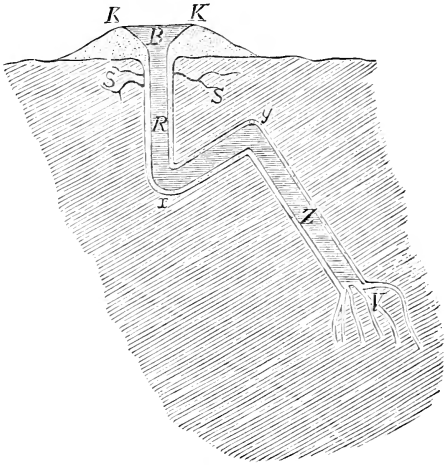


Fig. 3.

R, by which the waters are connected with the surface, is bent upward at x, to be bent downward again at y into the tube Z, which, reaching the depths of the earth, is connected with the channels V. These channels conduct to Z hot water mixed with steam, while R is supplied by the streams S, which lie near the surface, with cold water. The geyser-tube becomes stopped at x by the accumulation from these two sources, and the steam rising from Z, deprived of an outlet, collects at y. Its elasticity being augmented by the masses of steam that keep coming up, and by the continued accession of heat from Z, it forces away the water that is in contact with it, and gradually fills the connecting passage $x\,y$ and a part of Z, while it interposes a separation

between the water-columns R and Z. The water in R becomes heated by contact with the imprisoned steam, and will obviously attain a higher temperature in the lower than in the upper part of the geyser-tube R. Superheated water is produced in R as well as in Z, because the weight of the water in R and the upward pressure of the water, and the confined steam in Z, produce pressure and counter-pressure. As steam and water continue to rise from the channels V, the level of the water in $x\,y$ is depressed, for the steam can exercise its force only in the direction of R. As the expansive force of the steam increases, a greater quantity of water is driven over the rim of the basin till the force of the steam becomes so great as to exceed the weight of the column of water in R. Single puffs of steam escape, the elastic force of the vapor is slightly diminished, and a sudden development of steam is produced from the superheated water in Z, causing the whole column of water in R to be thrown forcibly into the air. The superheated water which has got into R during this movement is likewise converted into steam, increasing the effect. The conditions required by the last theory for the origin of an intermittent spring exist in nature. Volcanic forces produce suitable crevices, and the water, leaving siliceous deposits upon the walls, makes these clefts steam-tight.

The time which elapses between two successive eruptions varies in different intermittent springs. It depends upon the length and breadth of the whole geyser-shaft, and the distance to which it penetrates toward the interior of the earth. The temperature of the superheated water and the amount of steam that is formed from it are also largely dependent on the size of the spring. Thus, Strokr and the Little Geyser, intermittent springs in Iceland, also lying at the foot of Bjärnafell, have much stronger eruptions than the Great Geyser. The intermittent springs of the North Island of New Zealand are distinguished by their beautiful snow-white deposits of siliceous sinter, within which the water of the basin appears blue. The most imposing of known geysers are those of North America, of which the Giant shoots its jet to the height of two hundred and fifty feet.

A PREMATURE DISCUSSION.

By Mrs. Z. D. UNDERHILL.

IN her clever article upon "Science and the Woman Question," in "The Popular Science Monthly" of March, 1882, Miss Hardaker arrives at the definite conclusion that woman is and must necessarily for ever remain the intellectual inferior of man. In view of the importance of this conclusion, it will perhaps be worth while for a critic committed to neither side of the question to point out several flaws in

Miss Hardaker's argument, which show that, whether or not her final conclusion be correct, the proofs and reasoning which she adduces to sustain it do not fulfill that purpose.

In the first place, Miss Hardaker brings forward prominently the argument that, as the brain of man is larger than that of woman, therefore his intellectual ability must be greater. But she omits to first prove that size is an essential attribute of superiority. Some of the most intelligent members of the animal kingdom have also, as far as actual size is concerned, the smallest brains. Excluding man, no other animals have elaborated for themselves such complicated social systems as have ants and bees. There are many similar facts which tend to show that size of brain has only a relative instead of an independent value, and scientific investigations have not yet been carried far enough to establish the physiological bases upon which this relative value of brains is to be estimated. It is quite possible that it may ultimately be found to depend upon factors of which we as yet know nothing.

The argument that, as man has larger stomach and lungs than woman, he must consequently have more energy and more mental ability, is equally without a base in any such accumulation of exact facts as must always be the only foundation for trustworthy inductions. The fact that the elephant and horse have also larger stomach and lungs than those of man has not enabled them to surpass human beings in that complex evolution of mental and moral qualities which we agree to denominate superiority. The real material causes from which such superiority proceeds we have yet to discover; and, while it looks at present as though relative size of body and brain might be one among them, we have no such positive proof of this as would warrant resting an argument upon it.

As to the other arguments founded upon the supposed inferiority of intellectual vigor in women, owing to the discharge of their peculiar physiological functions, it is only necessary to repeat that the solution of this question involves a knowledge of the complicated workings and balances of the human system which we do not yet possess.

The argument for the intellectual superiority of man, based upon the supposed superiority of his intellectual achievements, shows the same unscientific disposition to draw conclusions before investigating facts. The mass of the female sex has been engaged since the beginning of civilization in two functions—the regulating of household life and the training of children—both undoubtedly involving intellectual activity. Reflection must make it obvious that it would be impossible to arrive at a correct conclusion as to woman's mental powers by comparing her achievements with those of man in fields which, as a sex, she has never entered. In order to rightly estimate her brain-power, it would be necessary to discover by long-extended and carefully collated research the amount of intellectual ability involved in the discharge of those functions to which her energies and intelligence have

been directed. The observations of one person are of no value as a foundation for argument; but it would perhaps here be pertinent for the writer to mention that, in her own experience of life, she has seen women who have not impressed her as inferior in mental ability to the men with whom they associated, and to whom the exercise of their duties, as the heads of households and the guardians of childhood (involving the many questions, abstract and practical, which these duties do involve), has seemed to afford scope for the greatest intellectual activity.

Considering the want of knowledge, of all but the most fragmentary facts, which meets us at the threshold of this question, it would seem that all the arguments on either side are wasted breath, and that those advocates deserve reprobation who would throw a false veil of scientific reasoning over their ignorance. It is a sufficient sign that no real study of the question has yet been made, when we find on both sides suppositions and feelings brought forward as arguments.

The only way in which such a problem can be properly approached is by the scientific methods of study which are now applied to other subjects: the painstaking accumulation, from all available sources and by many collaborators, of all the statistics and facts bearing upon it, the patient search for such truths connected with it as we are still ignorant of, and the application to all alike of unprejudiced investigation and strict logic. This has never yet been attempted.

THE RELATION OF MUSIC TO MENTAL PROGRESS.

By S. AUSTEN PEARCE, Mus. Doc., Oxon.

THE nature of music is threefold, like that of man to whom it appeals. Therefore, it may be regarded as a sensuous art, in that it delights the ear; as a psychologic art, in that it records the emotions, and requires mental operations on the part of the hearer for its due appreciation; and, as it involves agreements, differences, symmetries, complexities, etc., and order in apparent disorder, it may be regarded as a branch of science closely allied to mathematics.

The distances between the holes of a flute, the tension of a drumhead, the lengths of organ-pipes, the rapidity of vibrations, the intervals between recurring accents—in fact, all that may be surveyed and expressed in numbers in this art—give evidence of the mental power of the musician, irrespective of all considerations respecting the imagination or creative power in originating compositions.

The music of a people may be considered in direct relation to their supersensuous natures. From this point of view alone, strongly marked differences may be noted; for, by comparing modern Italian

music with German, it is at once seen that the latter is developed more highly in an intellectual sense.

Our modern music is styled a new art, chiefly because it requires advanced mental powers of a special kind on the part of composers and auditors. Instead of being a succession of monotones, it is a complex web of many tones, that the hearer must analyze to understand and enjoy. In the ordinary church-quartet there are four such interwoven threads; in a symphony by Beethoven, many more. An elaborate tonal plexus demands from the listener considerable mental effort, unless he has acquired by study a "polyphonic ear," or the power of perceiving the relationships of all the parts heard simultaneously, as clearly as one, looking down upon a ball-room scene, may perceive the symmetrical forms of a mazy dance.

It is interesting to consider the birth of a new art, and gratifying to note that our modern civilization is marked by so rare an event. We need not, therefore, lament that at the Renaissance no specimens of Greek music were forthcoming; for these might have influenced the early composers, whose special duty it was to strive to express the new thought and feeling of the time, and of the Latin and Germanic races, not of Greeks or Orientals. When the mental sleep of the dark ages passed to the waking dream or semi-consciousness of the middle ages that led to the complete awakening, there was great productive activity in all branches of art.*

But, whereas, in architecture, painting, poetry, dancing, sculpture, dramatic representation, etc., models of classic antiquity were at hand, in the department of music nothing came to light but the didactic treatises of the Greeks. These works, which were printed in Holland in the original text and studied carefully by musicians, failed to exercise any marked influence on the art, for there were no actual compositions found that would illustrate the theories so carefully elaborated. Our modern art, therefore, is no Euphorion, born of a Faust and Helen—of Christian and pagan ancestry—for there was no artistic dualism in music at the Renaissance.

Although the Church had, in the Bible, a foundation for poetical and musical art, it neglected Hebraisms. Being reared on classic ground, its first hymns and poetic forms were Greek and not Oriental. But this early Church music could not supplant that which missionaries found in Western countries. Strong as the Church was, in many senses, in those days, it could not hinder the introduction and recognition of the new polyphonic style. In this one particular it seemed powerless to dominate over the free spirit of man that thus formed for itself its own mode of expression. The musician was left unhampered in his actions, while throughout the Renaissance there was a constant struggle between the styles of the mediæval artists and

* See article in "The Popular Science Monthly" on the "Imperfections of Modern Harmony," vol. xvi, p. 510.

the classic models of antiquity in all the other arts. To this day, music has, in a technical sense, remained free from all admixture with relics of the dead past; and, although some of these may be hereafter discovered, it is doubtful if they would prove more than merely interesting to those thinkers who are ever desirous of enlarging their conceptions of the art by studying that of other peoples.

Such specimens could hardly have any vital power, however highly they might be prized, being too foreign to the experiences and requirements of our age to find willing ears. And this not because sympathy with the emotions expressed would not be accorded, or that the few sounds of the lyre would not prove sensuously agreeable, but because the structure of the music, in the third sense mentioned above, would prove so strange.*

We can not here define the Greek scales, nor contrast Occidental music with Oriental, Gothic cathedrals with Grecian temples, dramas of Shakespeare or Kalidisa with those of Sophocles, as regards relative complexity and simplicity, but must proceed to point out that as civilization arose in the West, music at least kept pace with it, if it was not greatly in advance of the intellect of the time, as it is now, when even Beethoven's latest quartets remain as sealed books. It has been noted that it was an important factor in the general Western illumination, and was most truly of it, while the other arts were represented by specimens that were in it but not entirely of it. These arts of visible representation of known things requiring less mental power than the invention of new forms that have no counterparts in nature or geometry, it does not appear strange that, while painting, sculpture, and architecture attained highest perfection long ago, music continues to make rapid advances in several directions, to open new schools, to pass through various phases—now being developed in one direction, now in another—that this art is expected to reveal hitherto unknown possibilities in the future. We have already grown beyond the deification of the bodily man, and seek the mystic inner soul. This makes the art of music so greatly in requisition. Our successors may go deeper still, and altogether cease to make reproductions of tangible things.

The relation of musical art to literature and general progress may be seen illustrated in the recent history of Germany. After the Thirty Years' War, which reduced her to material, mental, and moral poverty, she began to establish the Protestant religion, and to try to form into one coherent state a number of small principalities. Her literature was the expression of the national spirit, and yet helped to form this spirit. Luther invented the Choral, which remains to this day, not only the song of the Church, but the national song of the whole united people, their political song, their war-song, and one of the mightiest engines for developing in the minds and hearts of the people the sen-

* See article on "Oriental Music," vol. xviii, p. 241, in "The Popular Science Monthly."

timent of universal brotherhood. "Nun danket alle Gott," which won the battle of Leuthen, during the late Franco-German War, proved its influence over the people to be unimpaired.

Music and literature thence went hand in hand down to the school of the Romanticists, in which the middle ages became the ideal, and appeals were made to the national pride of the German. Then Wagner produced art-works that are similarly founded on national myths, and are more ambitious in scope and intention, as well as in musical and dramatic structure, than any works of his predecessors. Let us now take a broader historic but a narrower musical survey.

The Church accepted the musical teachings of Pythagoras and the astronomical theory of Ptolemy; and thus, for some unknown reason, progress was retarded. When the world accepted what the Church rejected, progress began in both sciences. For Ptolemy had demonstrated a new "section of the canon," by which our modern major scale was scientifically determined, and justified, and which made our harmony possible.

The invention of counterpoint in the north of England in mediæval times, and the subsequent practice of canonic forms of imitation, led to the general treatment of music on scientific methods by composers, however it obtained among the populace. In China we find music among the uneducated classes as unlike that of the musical mandarins as can well be imagined.

Subsequently, the discovery of harmony in nature opened a new realm to the musician. It was a revelation. It provided him with a scale of sounds analogous to that of color in the spectrum, and he soon determined the proportions mathematically. Hence a new science arose within the art of music, by which the composer no longer proceeded by a kind of "rule of thumb," but with a perfect knowledge of the ratios of speeds of vibrations, at which sounds would combine to form chords, as chemists after John Dalton learned to make new compounds unerringly.

The musician followed up the soft whisperings of Nature, until he found that each tone was attended by myriads of other tones as truly as attendant planets, asteroids, etc., surround a primary sun.

Heretofore music was made to conform to certain laws of proportion when viewed horizontally on the paper, but now it was made to conform to another series of laws, when regarded horizontally; the art of fugue was seen to be one of the greatest triumphs of the human mind, and the great universities in England instituted examinations for degrees in music, making the projection of an eight-parted fugue or canon in silence the supreme test of the mental prowess of each candidate.

It is thought that the opera was intended to be a resuscitation of the Greek drama, in which all was to be elevated and made musical. The music, however, differed but little from the prevailing style. It

is also thought that at the Crusades, when we learned so much from the Arabians, in mathematics, etc., we also acquired their musical systems, which are marvels of ingenuity and complexity; but these were utterly rejected, and the Arabians, on their part, refused to admire the little we could then accomplish with the new science of harmony. So little did our music take its rise in the East (although all our instruments originally came from thence), that the Irish harps and harpers were sent to Italy, where they gained the praises of Dante and Galileo. The Italians subsequently sent their sons westward, to learn counterpoint, as Americans now study in Europe.

In early times music was much more troublesome to learn than it is now. The instruments were difficult to tune, and keep in tune; and the notes had to be identified by the ear. Now, a deaf or ignorant performer may provide himself with the tonal system ready-made and symmetrically laid out as on a piano-forte finger-board. The complex nature of the new art demanded such a simplification, and some arrangement by which an executant might operate many notes at the same time. The advances made in the physical sciences generally, and especially in pneumatics, hydraulics, electricity, and acoustics, aided in the improvement of organs.

The mere act of reducing the musical dream to positive statement in writing marks a mental advance, especially when it is remembered that this notation has proved capable of recording conveniently the most highly elaborated forms of modern compositions. It is far simpler than the Chinese notation, and more direct than tablature, which gave directions how to find the notes, instead of indicating them directly by letters that form a kind of algebra. With this notation the musician has been able to avail himself of the printing-press, and thus to spread his apparently indescribable imaginings broadcast throughout Christendom. Singularly enough, his harmonies are still unappreciated elsewhere.

The study of comparative psychology has been followed up. Hence we now find in the works of Chopin an ideal reflection of the sorrows of the Polish people, long suffering from quarrels not of their own making; and, in the passionate music of the Italian, a marked contrast with the deeper-felt expressions of his Teutonic neighbor. Modern introspection, as in Byron's "Manfred" and Goethe's "Faust," finds its counterpart in the overtures of Schumann and Wagner, whose "Faust Overture" is acknowledged to be a portraiture of a definite soul-state.

Although the drama has declined, modern music has become preeminently dramatic. A symphony by Beethoven is an idealized form of the Shakespearean drama, rather than that of the Greeks; for it has not a mere trio of parts, but many; and a complex scheme of plots and counter-plots, incidental passages, etc. Its voices are persons (in the sense of *personare*, "to sound through"), and they are heard

simultaneously, not merely consecutively. The Wagnerian opera, therefore, that employs both visible and invisible characters, shows an advance worthy our present attainments.

It was stated above that, while other artists are occupied with the tangible forms of the external, visible world, the musician is busily engaged in the study of the human soul; yet it must be remembered that he has had to seek for the germs of his art in nature, and that these were hidden from him so deeply that they were hidden long.*

His resonator must be constructed to re-enforce some particular note which he supposes to be sounding, whereas the telescope of the astronomer reveals many unsought objects at once. And while the painter finds his forms and colors openly displayed, the musician must evolve his from within. He creates both form and spirit, and so entirely, that we can form no notion of the smallest tributary melody in any work we have not actually heard, or the score of which we have not seen.

If our civilization endures or progresses, there can be little doubt that the music of the future will continue to give evidence of the fact, even if it should not contribute to the general advancement.

DR. GÜNTHER ON THE STUDY OF FISHES.†

MANY difficulties, says the "Quarterly Review," tend to prevent ichthyology becoming a popular study, as the study of shells, insects, birds, or flowers is popular. However it may be with the particular species that anglers seek out and professional fishermen hunt, fishes as a class are not familiar objects. They keep for the most part out of sight, and when at liberty in their element can be detected only by passing glimpses, after which they are nearly always immediately lost. The aquarium, whatever it may have done to aid the study of the lower forms of aquatic animals, has contributed little or nothing to promote a real knowledge of ichthyology; and a preserved specimen of a fish is a most unsatisfactory object, as far as it can be from having anything of the color or the life or the grace of a real fish, and can not by any possibility be made to present a natural aspect.

Another serious difficulty in the way of the student of fishes may be stated thus: In beginning the study of any department of natural history, whether it relates to plants or to animals, the first effort is to find out characteristics of the smaller groups composing it, and to

* See article on "The Modern Piano-forte," p. 700, October, 1877, in "The Popular Science Monthly."

† An Introduction to the Study of Fishes, by Albert C. L. G. Günther, Ph. D., F. R. S., Keeper of the Zoölogical Department in the British Museum.

assort them in accordance with those characteristics; in short, to arrange or classify them. The young conchologist, for example, sees in an instant that out of a miscellaneous collection of shells some are bivalve and others univalve, and that some of them exhibit clear distinctions connected with the form of the animal to which the shell belongs. The young entomologist, with still greater ease, perceives the difference between most of the insects that come in his way, and indeed in some cases needs no instigation to look for them—the difference between a grasshopper and a house-fly, a beetle, a butterfly, and a moth, being self-evident to any one with eyes. So with the vertebrates; it requires no previous zoölogical instruction to enable any child to point out characters that will separate a snake from a tortoise, a rabbit from a sheep, a whale from a camel, and the rough primary division of all these creatures is at once perceptible. But with fishes this is not so. The learner, judging, as he is at first inclined to do, from outward survey, is surprised to find that the essential differences between a lamprey and an eel are deemed to be far greater than between an eel and a salmon, and that a skate is much further removed from a turbot than the latter is from a gudgeon, while a lancelet, which, when immersed in a bottle of spirit, looks so like a small smelt, differs, in the opinion of certain systematists, more from it than the smelt does from a frog, or indeed from any other existing vertebrate. All this, which the learner finds written in the first book on the subject (if he has one of the least authority) to which he has access, is so entirely in contradiction, as he thinks, to the plain evidence of his eye-sight, that he may well be staggered at the outset of his studies and discouraged from their prosecution. The classification of fishes has in truth been a task of no ordinary difficulty, and it is a subject requiring a far greater knowledge of their internal structure than can possibly be expected of a beginner.

One of the most formidable difficulties in the way of arriving at an intelligent classification has been removed by a discovery which Dr. Günther has made concerning the affinities of certain groups of fishes or fish-like animals, the relations of which to each other and to other fishes had been an inscrutable puzzle to all systematists. Among these were the ganoids, a family represented in an indefinite number of fossils, mostly of very ancient date, but few types of which survive to this day, and these restricted to the fresh waters of Eastern Asia, North America, and tropical Africa; other fossil fishes of equal antiquity, which were closely allied to the abundant sharks, dog-fishes, rays, and skates of our own seas, the "Chondropterygians" or "Elasmobranchs"; sturgeons, "Chondrosteans," possessing much of an archaic character; and besides these, there now exist two animals, commonly called "mud-fish," scientifically "Dipnoi," which have been deemed by some great authorities true fishes, by others amphibians. Furthermore, in the early days of the settlement of the Australian

colony of Queensland, accounts were given of the existence in the rivers of the country of a large fish which the colonists called a "salmon," from the fact of its having salmon-colored flesh, and of sometimes, it was said, rising to a fly. Mr. Krefft, Curator of the Australian Museum, at Sydney, having examined a specimen of this fish in 1869 or 1870, pronounced it to be allied to the mud-fish, but discovered also that it possessed teeth so closely resembling those of certain fossil fishes attributed by Agassiz to the sharks, that no doubt could be entertained of the generic identity of the two forms. Accordingly, the newly found animal was described as a species of *Ceratodus*—that being the name which Agassiz had conferred on the creatures whose fossil teeth he had long before made known. Now, all this was in itself sufficiently remarkable, for it proved that *Ceratodus*, as a genus, had persisted from the Mesozoic era ; but its important bearing was not fully perceived till after some more examples had been obtained and sent to Dr. Günther. He described the recent *Ceratodus* in great detail in the "Philosophical Transactions" for 1871, and was able, furthermore, by its means, to show how the palæozoic as well as the recent ganoids, the sharks and skates—both ancient and modern—the sturgeons, the mud-fishes, with some other forms that had hitherto been irreconcilable, could all be brought together through some essential characters common to the whole of them, and harmoniously placed in a single class, to which he assigned the name of "Palæichthyes"—fishes of ancient type. Professor Huxley had previously pointed out the affinity of the mud-fishes to certain ganoids, but the credit of discovering this comprehensive classification is due to Dr. Günther.

Dr. Günther does not undertake to describe definitely the geographical distribution of fishes in the sense in which the term geographical distribution is used by naturalists of other branches, he holding that "the endeavor to establish, by means of our present fragmentary geological knowledge, the divisions of the fauna of the globe leads us into a maze of conflicting evidence." It is obvious that fishes are not amenable to the laws of geographical distribution which govern land-animals. In treating of their relations in this respect it is, moreover, necessary to separate them into categories, of which Dr. Günther makes four : 1. Fresh-water fishes ; 2. Brackish-water fishes ; 3. Marine fishes, which are furthermore subdivided into shore-fishes and oceanic or pelagic fishes ; and, 4. Fishes of the deep sea. Even in the case of fresh-water fishes, which of course live under conditions more similar to those of land-animals than do those of the other categories, he disallows the six great zoögeographical regions which most geologists have accepted, and would arrange them in three zones—Northern, Equatorial, and Southern. These zones, are, however, broken up into regions, which roughly correspond with the six generally received, except that the Australian region of most zoögeographers is split up into

two, the "Tropical Pacific" and the "Antarctic" region, the last including the Patagonian seas as well as those of New Zealand and Tasmania. The fishes of the second category (brackish water), owing to the fact of their living in salt-water equally with fresh, and thus being able to spread readily over the globe, can not help in any plan of parceling out the earth's surface into districts. The shore-fishes afford a somewhat better definition, and of them five groups are formed, which inhabit respectively the Arctic Ocean, the Northern Temperate Zone, the Equatorial Zone, the Southern Temperate Zone, and the Antarctic Ocean. The pelagic fishes seem to require separation, but as little can be deduced from them as from the inhabitants of brackish waters, and they insensibly mingle with the fishes of the deep sea.

Thirty years ago no one had the audacity to believe that the abysses of the ocean were tenanted with piscine life. Even animal life of any sort had been supposed to be impossible at a greater depth than that which has now been found to be but the portal of a new world of beings. The discovery of what has since been proved to be deep-sea forms of fishes began indeed long ago, but the abysmal nature of their haunts was hardly suspected, and certainly not recognized till much later, when the fact was established by Dr. Günther, conjointly with the late Mr. James Yate Johnson. On this subject Dr. Günther says: "The knowledge of the existence of deep-sea fishes is one of the recent discoveries of ichthyology. It was only twenty years ago, that, from the evidence afforded by the anatomical structure of a few singular fishes obtained in the North Atlantic, an opinion was expressed that these fishes inhabited great depths of the ocean, and that their organization was specially adapted for living under the physical abyssal conditions. These fishes agreed in the character of their connective tissue, which was so extremely weak as to yield to, and to break under, the slightest pressure, so that the greatest difficulty is experienced in preserving their body in its continuity. Another singular circumstance was, that some of the specimens were picked up floating on the surface of the water, having met their death while engaged in swallowing or digesting another fish not much inferior, or even superior, in size to themselves. The first peculiarity was accounted for by the fact that, if these fishes really inhabited the great depths supposed, their removal from the enormous pressure under which they lived would be accompanied by such an expansion of the gases within their tissues as to rupture them, and to cause a separation of the parts which had been held together by the pressure. The second circumstance was explained thus: a raptatorial fish, organized to live at a depth of between five hundred and eight hundred fathoms, seizes another usually inhabiting a depth of between three hundred and five hundred fathoms. In its struggles to escape, the fish seized, nearly as large or strong as the attacking fish, carries the latter out of its depth into a higher stratum, where the diminished pressure causes such an expansion of gases as

to make the destroyer, with its victim, rise with increasing rapidity toward the surface, which they reach dead or in a dying condition."

It was also shown that, as the same species and genera are found in the most distant parts of the globe, the deep-sea fishes are not limited in their range, and consequently, as is admitted on other grounds, that the physical conditions of the ocean-depths must be much alike all the world over. That the deep-sea fishes are not of a peculiar order, however peculiarly organized, but are for the most part modified forms of surface-types, was another conclusion arrived at from the scattered evidence available before dredging at great depths was systematically practiced, and a conclusion that has since proved to be right. Nevertheless, it still remained to ascertain more precisely the bathymetrical horizons in which the different kinds lived, and this has been to some extent attained by observations made during the voyage of the Challenger; but these can not be received without further critical examination, for, unfortunately, no precaution seems to have been taken to keep the mouth of the dredge closed, and therefore it is probable, if not in some cases certain, that fishes were occasionally entrapped while the machine was passing through the surface-water. On the other hand, the majority of the examples taken in the dredge offer literally internal evidence that they were inhabitants of the abysses, being so organized as to be unable to live near the surface, and consequently that they were captured at the greatest depth to which the dredge reached, or nearly so.

The physical conditions of the deep sea, affecting the organization and distribution of these fishes, are thus formulated by Dr. Günther:

1. "Absence of Sunlight.—Probably the rays of the sun do not penetrate to, and certainly do not extend beyond, a depth of two hundred fathoms; therefore, we may consider this to be the depth where the deep-sea fauna commences. Absence of light is, of necessity, accompanied by modifications of the organs of vision, and by simplification of colors.

2. "Phosphorescence.—The absence of sunlight is in some measure compensated for by the presence of phosphorescent light, produced by many marine animals, and also by numerous deep-sea fishes.

3. "Depression and Equality of the Temperature.—At a depth of five hundred fathoms the temperature of the water is already as low as 40° Fahr., and perfectly independent of the temperature of the surface-water; and from the greatest depths upward to about one thousand fathoms the temperature is uniformly but a few degrees above the freezing-point. Temperature, therefore, ceases to offer an obstacle to the unlimited dispersal of deep-sea fishes.

4. "The Increased Pressure by the Water.—The pressure of the atmosphere, on the level of the sea, amounts to fifteen pounds per square inch of surface on the body of an animal; but the pressure amounts to a ton weight for every one thousand fathoms of depth.

5. "With the Sunlight, Vegetable Life ceases in the Depths of the Sea.—All deep-sea fishes are therefore carnivorous; the most voracious feeding frequently on their own offspring, and the toothless kinds being nourished by the animalcules which live on the bottom, or which, 'like a constant rain,' settle down from the upper strata toward the bottom of the sea.

6. "The Perfect Quiet of the Water at Great Depths.—The agitation of the water, caused by the disturbances of the air, does not extend beyond the depth of a few fathoms; below this surface-stratum there is no other movement except the quiet flow of ocean-currents, and near the bottom of the deep sea the water is probably in a state of almost entire quiescence."

Now, the effect of these conditions on some part or parts of their structure is such that all deep-sea fishes are easily recognizable, without positive evidence of their having been caught at a great depth; and in many of them the most striking characteristics relate to the pressure of the water they inhabit. Their bones and muscles are comparatively feebly developed; the former "have a fibrous, fissured, and cavernous texture, are light, with scarcely any calcareous matter, so that the point of a needle will readily penetrate them without breaking." They are loosely attached to each other—the vertebræ especially; and, unless carefully handled, the body will almost certainly fall to pieces. But that this is not the animal's normal condition we may be well assured. It is due simply to the absence of the pressure which keeps the whole organization compact; for, as has just been stated, most of these fishes are rapacious, and to indulge their enormous voracity they must execute rapid and powerful movements, to effect which their muscles must be as firm and their vertebræ as tautly braced as in their surface-swimming relatives. Marvelous as this is, it is far from being all that is marvelous in the structure of these dwellers in the profundities. Besides modifications of their eyes, such as are found in several other groups of animals, many of them are furnished with "more or less numerous, round, shining, mother-of-pearl-colored bodies imbedded in the skin," of which Dr. Günther says: "These so-called phosphorescent or luminous organs are either large bodies of an oval or irregularly elliptical shape placed on the head, in the vicinity of the eye, or smaller round globular bodies arranged symmetrically in series along the sides of the body and tail, especially near the abdominal profile, less frequently along the back. . . . The organs of one kind consist of an anterior, biconvex, lens-like body, which is transparent during life, simple or composed of rods; and of a posterior chamber, which is filled with a transparent fluid, and coated with a dark membrane composed of hexagonal cells or of rods arranged as in a retina. . . . In the other kind the organ shows throughout a simple glandular structure, but apparently without an efferent duct. Branches of the spinal nerves run to each organ, and are distributed

over the retina-like membrane or the glandular follicles. The former kind of organs are considered by some naturalists true organs of vision (accessory eyes), the function of the latter being left unexplained by them."

There can hardly be a reasonable doubt that the functions of these organs, of both kinds, have reference to the conditions of light under which the animals live, but further than that judgment concerning them must be suspended. Dr. Günther briefly states three hypotheses that have been broached as possible: 1. That both kinds are "accessory eyes," to which the objection is offered that several fish having well-developed and even large eyes, perfectly adapted for seeing in the dark, are endowed with them, while in other deep-sea fishes, without external eyes, they are absent. 2. That only the organs with a lenticular body and a retina-like membrane behind it are visual, but that the glandular organs are phosphorescent; and more may be said for this view than for any other, since the glandular organs are certainly luminous. 3. That all the organs are producers of light, in which case it must proceed from the inner cavity and be emitted through the lens-like body as through a bull's-eye lantern. It will be hard to decide which of these suppositions is the right one, for it seems impossible to reproduce in the animals and their environment on the surface the conditions of an uninterrupted deep-sea life. [This subject was fully discussed by Dr. Ernest Krause in the last number of "The Popular Science Monthly."]

The deep-sea fishes display few colors. Their bodies are generally black or silvery, with a most brilliant sheen, which is preserved even after years of immersion in spirits. A few are "picked out" with bright scarlet, either on the fin-rays or the filaments attached to them. These filaments, it may be said, are eminently characteristic of fishes that inhabit still water, and the fact that many of the deep-sea forms are adorned with them perfectly accords with the belief that the abysmal regions are quiet.

Another remarkable property of some of these creatures is the possession of a stomach so capable of distention that it can hold a prey of twice or thrice the bulk of its destroyer. Dr. Günther gives figures of two or three fish with distended stomachs; and Mr. Johnson, his associate in this investigation, writes of a specimen which he procured at Madeira:

"The man from whom I obtained it stated that he had a fish with two heads, two mouths, four eyes, and a tail growing out of the middle of the back, which had astonished the whole market; and the fishermen, one and all, declared they had never met with anything like it before. At first sight it really did appear to be the monster described; but a short examination brought to light the fact that one fish had been swallowed by another, and that the features of the former were seen through the extensible skin of the latter. On extracting the fish that

had been swallowed, it proved . . . to have a diameter several times exceeding that of its enemy, whose stomach it had distended to an unnatural and painful degree." The action performed by the fish in these cases is not, however, a real swallowing, but more like the similar process executed by serpents.

The interest of Dr. Günther's book does not end with the account of deep-sea fishes, but the chapters devoted to that subject and to classification illustrate the most striking discoveries that have been recently made in ichthyology. Among the curiosities of fish-life that please and amuse as well as instruct, is the story of the fighting-fish of Siam, which, on seeing another of its species, or even its own image, in a mirror, becomes suddenly excited, and of which, though it is dull in hue at other times, "the raised fins and the whole body shine with metallic colors of dazzling beauty, while the projected gill-membrane, waving like a black frill round the throat, adds something of grotesqueness to the general appearance." The Siamese are infatuated with the combats of these fishes, staking on the results considerable sums, and sometimes their persons and families, while the license to exhibit fish-fights is farmed, and brings in no small revenue to the royal treasury.

The peculiarity of the flounders, and other flat fishes, by which the eyes, normally situated in the young, move around as the animal grows, until they are both on the same side of the body, is well known, but the manner in which the transposition is effected is still in question. There is, moreover, no end to the wonders to be found in fishes' eyes. Those of the genus *Anableps*, known in Demerara as "four eyes," have the iris horizontally divided by a black band, which almost justifies their name; and as these fishes frequently swim with the head half out of the water, it is presumed that the upper and lower portions of the cornea are adapted for the different density of the media in which they are respectively used. The "star-gazers" (*Uranoscopus*), and others, have eyes that can be raised or lowered at will; but the most remarkable instance of mobility in these organs seems to exist in certain gobies of the genus *Periophthalmus* and its ally *Boleophthalmus*, which might be called "oglers," as they have the power of thrusting their eyeballs far out of the socket, and turning them as freely as a chameleon rolls his. These fishes are also remarkable for another faculty, toward which their versatile eyes must contribute not a little. At low water they remain on the muddy flats, and hunt for their prey, which consists of small crustaceans and other marine animals, making rapid leaps by the aid of their fins and tails, which are strong; and when their eyes are retracted they are protected by a membranous lid.

Then the fishes that travel over land, the flying-fishes, with the controversy as to whether they really fly or only seem to (with Dr. Günther denying the reality of the flight, and others affirming it from their personal observations), and the fish that build nests, like the

stickleback, and the fishing-frog, or angler, and the salmons and the cod, and the herring, afford inviting objects of curious observation, or scientific and economical study or speculation, concerning the later results of which we have kept the readers of "The Popular Science Monthly" informed. The last fish we notice is the eel, the manner of the reproduction of which is yet a puzzle to naturalists. Dr. Günther says of it:

"Their mode of propagation is still unknown. So much only is certain, that they do not spawn in fresh water, that many full-grown individuals, but not all, descend rivers during the winter months, and that some of them, at least, must spawn in brackish water or in deep water in the sea; for in the course of the summer young individuals, from three to five inches long, ascend rivers in incredible numbers, overcoming all obstacles, ascending vertical walls or flood-gates, entering every larger or smaller tributary, and making their way even over *terra firma* to waters shut off from all communication with rivers. Such immigrations have long been known by the name of 'eel-fairs.' The majority of the eels which migrate to the sea appear to return to fresh water, but not in a body, but irregularly, and throughout the warmer part of the year. No naturalist has ever observed these fishes in the act of spawning, or found mature ova; and the organs of reproduction of individuals caught in fresh water are so little developed, and so much alike, that the female organ can be distinguished from the male only with the aid of a microscope."

THE DEVELOPMENT OF CITIES.

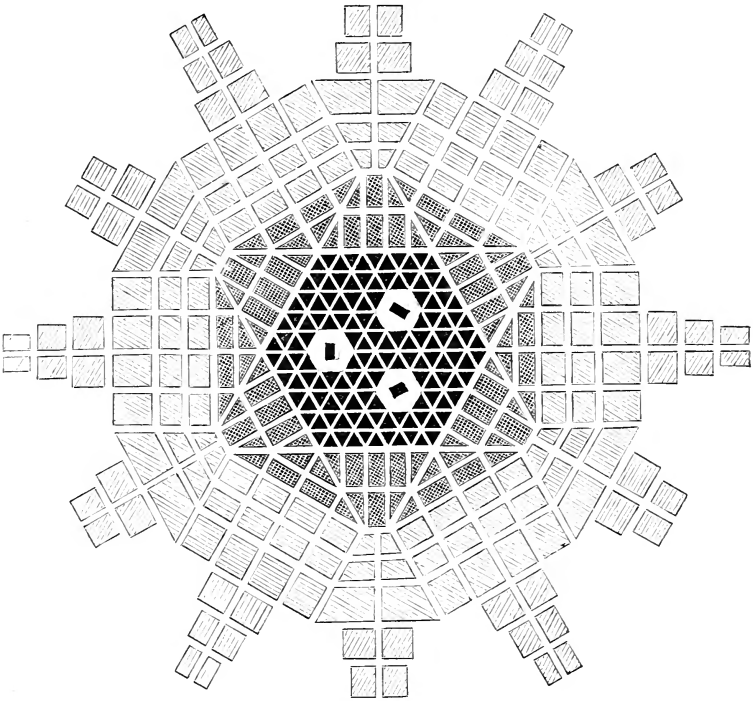
BY M. BADOUREAU.

THE rectangular system of laying out streets has the advantage of extreme simplicity, and lends itself to a convenient adjustment of the interior of the houses of a city; but it is monotonous in the extreme, and makes communication between one quarter of the town and another very inconvenient; for the passenger is compelled to go along the two sides of a triangle to accomplish the distance represented by its hypotenuse. We have endeavored to solve the problem of the best way of arranging the streets of cities by mathematical calculations, but have found the task one leading to geometrical complications. We recommend the study to geometricians as an interesting one, and content ourselves here with stating the conclusions we have reached. We have examined the question in the two forms: By what law can we arrange the streets so as to lose the least possible amount of space, and still have the greatest possible length of roads; and, given a surface of which the shape and area are known, and the law of

the division of the population having been ascertained, how shall we lay out the roads so as to make the different lines of communication, particularly the most frequented ones, as short as possible? Four plans ordinarily present themselves under which the ground selected for our city to be built on may be laid out: the square, hexagonal, octagonal, and circular. Of these, the hexagonal type seems, according to our mathematical calculations, the one which gives the greatest length of streets and the greatest amount of habitable surface, with the smallest consumption of space. As a rule, for cities the population of which is homogeneous, the octagonal and hexagonal plans are much preferable to the square in respect both to the utilization of the surface and the facility of communications. Unfortunately, both plans are liable to the objection that they give house-lots having acute angles of sixty degrees in the hexagonal, and of forty-five degrees in the octagonal plan. Practically the population finds it convenient to bear toward the center of the city, and, the more it bears that way, the more it is to its interest to do so. Consequently, the density of the population diminishes from the center toward the circumference. Under such conditions, the circular plan is very satisfactory. It has in effect the double advantage of furnishing direct roads to the center of the town, and of accommodating itself to giving to the houses in the outlying quarters the greater amount of space they require. For the center of cities, where the population is compact and homogeneous, where land is dear and communication is needed in every direction alike, the hexagonal plan, with the reservation of a few places for public monuments, is most convenient. This central part might be surrounded by a boulevard, beyond which the circular type might be adopted with modifications so as to avoid curved streets. The principal streets of each suburb might be directed toward the center of the city, and each suburb might in itself be laid out more or less according to the rectangular type. The transverse streets would, however, spread farther apart as the distance from the center became greater; and main diagonal streets might be arranged to cross the whole city, with few or only slight deviations. Beyond the suburbs, the principal radial streets might be continued for a considerable distance farther, but the transverse streets would nearly disappear. The accompanying design has been drawn according to these principles. It is worthy of remark that the sketch is more like the European cities that have grown up by progressive additions than the American cities which have been built on a so-called rational plan.

So far we have considered the question from an exclusively geometrical point of view. We may continue our study by referring to the influences which geographical, meteorological, commercial, and political conditions have had in the laying out of cities. Certain directions in the ways of communication are often imposed by the topographical situation; as, for example, when the town is crossed by a river or a

highway. Some cities are free to extend over the plain in any direction, while others are restricted to narrow valleys, or to islands of which they cover the whole. The city of Cadiz, confined upon an island, has very high houses, with terraces and lookouts, the object being to reach a height where the air will be healthy and the rainwater pure. St. Malo is built much after the same fashion, and the



streets in both cities are very narrow. Every one knows that the principal highways in Venice are canals, and that the several islands are traversed by prodigiously narrow and crooked streets. On the other hand, the cities of Hungary extend over considerable spaces and are thinly populated. The city of Maria Theresa, or Szabadka, for instance, according to E. Reclus, covers a space of eight hundred and ninety-six square kilometres, and is really nothing but a province cut up by regular avenues, by the side of which houses stand at intervals —an oäsis of stone in the immense plain.

We may remark, with respect to the bearing of climate, that narrow and crooked streets protect the inhabitants against heat and against cold, but they foster the accumulation of miasms and prevent the circulation of air. Cities tend to expand on the side from which the prevailing winds come. It is the most pleasant side, because it is free from the unhealthy emanations of the town.

In considering the economical side, account must be taken of the density of the population and the frequency of communications. It is important that the principal centers be connected by wide, direct, and easy roads following the course of the most usual commercial currents. Theoretically, the width of each street should be proportionate to the traffic upon it.

Historical considerations may sometimes rule, for due force must be allowed to existing conditions in the construction of each new street.

Sometimes cities are built so fast that we might say they are made up of sections constructed after a plan framed in advance. In such cases they generally present a regular disposition. Such a town is Carlsruhe, in Baden, where the avenues converge toward the Château, and of such character are most American cities. Generally, however, in old Europe, cities develop themselves slowly, and the laying out of their streets has been influenced by the circumstances in their history.

Open cities generally expand gradually by the building of houses along the roads toward neighboring towns. They thus take a kind of radiated or palmate form, quite favorable to facility of communication.

Fortified cities are developed in an intermittent way. After having been for a long time smothered within their walls, they end by breaking the barriers down and uniting with their suburbs; constructing elegant boulevards in the places formerly occupied by their fortifications. The city of Paris bears the marks of several changes of this kind. Generally the extension takes place alike in all directions, and the towns that have undergone such metamorphoses present a succession of concentric zones separated by circular boulevards. The central nucleus generally offers a close agglomeration of high houses parted by narrow, crooked, and everywhere crowded streets. Here public and private business is transacted, and the centers of trade and amusement, the public offices, and the churches, are established. Through this part also lie the usual ways of passage from one suburb to another. Most frequently the old town is traversed by a grand artery, the history of which goes back to the origin of the place, and which is usually busy with trade and much crowded. The population of the suburbs is generally less dense than that of the city proper; and the streets are wider, and the houses farther apart. The inhabitants of the suburbs are in the habit of going frequently to the center of the city, because it is the most populous part, and because the roads to the other suburbs lie through it. The principal streets of the suburbs also converge toward the center.

All the characteristics we have sketched may be found in the city of Vienna, where the ancient city, still called *die Stadt*—"the City," rests on a branch of the Danube in the north, and on the Wien in the southwest. The cathedral, situated in the center of the town, St. Stephen's Place, and the Graben, are still the points toward which the

Viennese and strangers are most in the habit of resorting; thence bear toward the north and toward the south, the Kärntnerstrasse and the Porte Rouge Street, so as to form a grand artery traversing the whole of the ancient city. One of the finest boulevards in the world has been built on the site of the fortifications that surrounded the place in the east, south, and west; and beyond this "Ring," as well as on the north side of the branch of the Danube, vast suburbs, regularly laid out, extend in every direction, enlarging tenfold the surface of the city.

Sometimes circumstances prevent the development being equal in every direction. The city of Antwerp, resting on the Scheldt, presents, with the suburbs that have recently been annexed to it, a semicircular form. Calais has only one suburb, much more populous, it is true, than the city itself; and the fortifications which separate the town and its suburb are to be razed and replaced by boulevards. Dismantling is not the only agency by which the aspect of cities may be suddenly modified. A great fire, for example, destroyed the central part of the city of Rennes in 1720, after which a new town, with high houses, wide, straightened, and rectangular streets, and handsome squares, was built in place of the burned one. A few old quarters, which the fire had spared, formed an ugly enough inclosure for this new town, which still partly exists. At the same time the suburbs have stretched out along all the principal roads, and a few new quarters have been built in the healthiest part of the suburban zone. At other times the hand of man destroys entire quarters, to reconstruct them in a more convenient and more hygienic manner. In such cases the worst quarters are the first to suffer transformation, and become in their turn the most elegant ones. The example set in Paris, under the administration of M. Haussmann, has been extensively followed in other cities in France and abroad. The construction of new basins in seaports also frequently leads to radical modifications of the aspect of the towns and in the grouping of their streets. We are evidently very far from exhausting the questions that grow out of the subject; but we hope we have succeeded in showing how complex and interesting they are, and how imperfect is the plan of those cities that are laid out in a net-work of rectangular streets.—*Translated from the Revue Scientifique.*

SKETCH OF PROFESSOR S. S. HALDEMAN.

THE career of Professor Haldeman illustrates how a student, who has his heart in his work, may excel as a specialist in more than one branch of science; and shows how the enthusiastic investigator, seeking light from all sides on the point he has under investigation,

may be led by the natural course of his work from one branch to another, which at first view seems quite distinct from it. Professor Haldeman was in his early youth a collector of living objects around his father's estate, and thus laid the foundations, in his recreations, for the eminence he afterward reached as a naturalist. Then, having turned his attention to ethnology, he was drawn to the study of languages and philology, and became one of the most distinguished American scholars and authorities in those branches. Next, he became interested in archæology, and contributed to that subject in his papers before the American Association of 1880, the last literary labors of his life. His success in all of these branches appears to have been owing to the adaptation of his natural tastes, and these to have been developed from inherited peculiarities.

Samuel Stehman Haldeman was born, August 12, 1812, at Locust Grove, on the Susquehanna River, twenty miles below Harrisburg, Pennsylvania. His family were of Swiss descent, had possessed the extensive estate which was their home for several generations, and occupied a considerable social position. His great-grandfather was a member of a local Committee of Public Safety in Revolutionary times; his great-uncle was the first Governor-General of Canada under British rule; his grandfather was a member of the General Assembly of the State in 1795. A niece of his great-grandfather and great-uncle, Mrs. Marcet, born Jane Haldimand, was a celebrated scientific writer, distinguished as the first who attempted to popularize science, by the publication of her "Conversations" on chemistry, natural philosophy, botany, mineralogy, language, and political economy. Professor Haldeman derived his middle name from the maiden name of his mother, Frances Stehman, who was an accomplished musician, and transmitted to him that correct ear for the notation of sound that made him in after-life so accomplished a phoneticist. His father was a man of literary tastes, and warmly encouraged the son's aspirations in a direction congenial to his own. Young Haldeman's education, till he was thirteen years old, was carried on in the local schools and his father's library. No little of it was gained on the farm, where he made the collections of specimens in natural history, which he was taught by a Methodist minister how to prepare, and of aboriginal stones and implements, which constituted his first museum, in the loft of the family carriage-house; and where he gathered shells, he says, on the banks of the Susquehanna long before he knew the meaning of genus and species.

When five years old he was a fellow-scholar with Daniel Engle, who could not speak English, but could spell in German, and sat with him. Young Haldeman soon discovered that his companion could spell in another language, and engaged him to bring his German spelling-book to the school, so that he could learn to do the same. The book was brought, and carefully hidden, to be studied in secret.

The teacher found the boys out, and forbade their studying German during school-hours, but allowed them to do so at recess and noon, when he also took a part in the exercise.

In 1826 Haldeman was taken to Harrisburg, to the classical school of Dr. John Miller Keagy, a "great teacher," who, besides the classical languages, "knew Hebrew, German, and French. He had a taste for the natural sciences, and in the absence of class-books he taught orally in an excellent conversational style." He remained two years at this school, and was then sent to Dickinson College, where his scientific tastes were encouraged by Professor Rogers, afterward State geologist. The stereotyped course of study of the college was not consonant with his own views of how his faculties should be trained, and he left the institution after two years, to take the superintendence of his own studies. He became ostensibly engaged with his father in conducting a saw-mill, but spent much of his time in field-studies, and with his books, concerning which he wrote at the time: "I developed a taste for rainy weather and impassable roads; then I could remain undisturbed in the perusal of my books, a supply of which I kept in a back office, where I retired as soon as the sky looked threatening." In 1833-'34 he attended the lectures of the medical department of the University of Pennsylvania, but without any design of becoming a physician. In 1835 he was married to Miss Mary A. Hough. Shortly afterward he removed to Chickies, Pennsylvania, to the house which he occupied till the end of his life, and became a silent partner in the iron business conducted by his brothers, Dr. Edwin and Paris Haldeman. In connection with this business he wrote two papers for "Silliman's Journal," on "Smelting Iron with Anthracite Coal," and edited, in 1855, a revision of Taylor's "Statistics of Coal." "In his residence at Chickies," says Dr. D. G. Brinton, in his memorial before the American Philosophical Society, "books and cabinets accumulated under his laborious hands, only to be scattered again and give place to others when his insatiable appetite for knowledge led him into new fields of investigation. For forty-five years he spent most of his time in his library, where, in his vigorous manhood, he worked sixteen hours a day. For, though he accepted several professorships, and delivered a number of courses of lectures, he did so with reluctance, preferring to be master of his time, and to spend it in the quiet of home."

He received from Professor Rogers an appointment as assistant on the Geological Survey of New Jersey in 1836, and of Pennsylvania in 1837. His field of work in Pennsylvania embraced that part of the State lying between the Blue Mountain and the South Mountain, the most important division, geologically, in the State. While engaged upon it he discovered the fossil plant, *Scolithus linearis*, the most ancient organic remains found in Pennsylvania, on which he published a monograph in 1840. During this period he also recorded the observations, real discoveries, that the peregrine falcon makes its nest in

rocks, as in Europe, and not in trees, as Wilson and others had supposed; and that the American eagle is a fishing-eagle, robbing fish-hawks when he can, diving himself after fish when he has to. He also discovered and described a new species of trilobite in Pennsylvania, which Professor Hall named after him.

Professor Haldeman's first publication was made in 1835, the year of his marriage, and was a paper in the "Lancaster Journal," exposing the falsity of the celebrated "Moon Hoax," published by Richard Adams Locke in the New York "Sun." He also published, in connection with his labors as a naturalist, a work on the "Fresh-Water Univalve Mollusca of the United States," in nine parts, 1840 to 1866; three numbers of a series of "Zoölogical Contributions"; "Outlines of the Zoölogy of Pennsylvania"; a sketch of the natural history and geology of Lancaster County, Pennsylvania; a monograph on the genus *Leptoxis* for a French work; an article on the "Zoölogy of the Invertebrate Animals," for the American edition of the "Iconographic Encyclopædia"; and seventy-three papers which Professor Agassiz has enumerated as having appeared in the scientific and philosophical journals and "Transactions" of the United States up to 1852.

"Dr. Haldeman," says Mr. C. H. Hart, "very early took a deep interest in the languages of the North American Indians, and, as an aid to the study of ethnology, he now devoted his attention to the study of language in general; and doubtless it will be as a learned and accurate philologist that his labors will be most remembered. His investigations in this most interesting study were not directed so much to the origin and source of language as to rendering it facile of acquirement and expression—his specialty being the notation of the elementary sounds uttered by the human voice in speech; thus reaching the form of language, which is merely the peculiar method of uniting thought with sound." The first result of these labors in this department was the paper entitled "Some Points in Linguistic Ethnology, with Illustrations chiefly from the Aboriginal Languages of North America," which was published in the "Proceedings of the American Academy of Arts and Sciences," in October, 1849. A work on the "Elements of Latin Pronunciation," which was published in 1851, and was warmly received, was an indirect result of studies which he pursued with the object of finding a way to adapt the Latin alphabet, while adhering strictly to its Latin signification, to the representation of the sounds of the native Indian languages. From this he was led on to pure linguistic studies, the fruits of which appeared in his "Investigation of the Power of the Greek β, by Means of Phonetic Laws" (1853), in a monograph "On the Relations between Chinese and the Indo-European Languages" (1856), and in his report to the American Association for the Advancement of Science "On the Present State of our Knowledge of Linguistic Ethnology." Having delivered some lectures on the "Mechanism of Speech" before the Smith-

sonian Institution, he entered the competition for a prize of one hundred pounds offered by Sir Walter Trevelyan, President of the Phonetic Society of Great Britain, for the best essay "On a Reform in the Spelling of the English Language"; to contain among other features "an analysis of the system of articulate sounds, an exposition of those occurring in English, and an alphabetic notation, in which as few new types as possible should be admitted." The result of this effort was a work on "Analytic Orthography," which, even before it had been revised in accordance with the suggestions of the donor of the prize, was preferred to the essays of seventeen competitors, all learned European philologists, and which was published in 1860. Five years afterward appeared a work on "Affixes: in their Origin and Application exhibiting the Etymologic Structure of English Words," which was pronounced, by a writer in the "Contemporary Review," "a collection more rational, complete, and exhaustive of the component parts of our language than we have had any good right to hope for within the present century."

Professor Haldeman was one of the founders of the American Philological Association, and was its first vice-president 1874–'76, and its president 1876–'77. He contributed many papers to its "Transactions," the first of which, on the "German Vernacular of Pennsylvania," was afterward extended, under the light of new studies, at the request of the Philological Society of London, into "Pennsylvania Dutch; a Dialect of South German, with an Impression of English," which was published in 1872. His last published philological work, "Outlines of Etymology," had in view the teaching of this as other sciences are taught, and appeared in 1877.

To this department of Professor Haldeman's activity belong his labors in behalf of reform in the spelling of the English language, in connection with which he presided at the International Convention on the subject held in Philadelphia in July, 1876, when the Spelling Reform Association was organized, and he was made one of the vice-presidents. His address to the American Philological Association at the close of his presidency in 1877 was devoted mainly to this reform.

Of his attainments in philology, Professor March says: "Professor Haldeman was in early life and by his mental constitution a scientist, and he took hold of the facts of speech in that spirit. He had a delicate ear and flexible organs of speech, and could pronounce with ease the most unutterable scientific vocables. His scientific habit enabled him to watch and describe the movements of the organs in producing all sorts of sounds, and to give the physical processes or causes of the changes in the sounds of words from age to age. He devoted much study to these subjects, seeking living speakers of every nation and tribe, and imitating and recording their peculiarities. He applied his knowledge of the laws of letter-change to etymology—chiefly, so far

as I know, to the derivation of English words and affixes. His text-books on that subject are full of ingenious observation and careful scientific deduction. He was also a great reader of old English books in their early editions, and he treasured in his memory the curiosities of spelling and pronunciation, the rhymes and puns and the like which he found there. He busied himself also with the Pennsylvania Dutch, as it is called, and traced it to its sources in Europe. He read largely the German works on the science of language, but he was an independent observer, and more likely to be biased by his critical temper than by absorption in any systems."

Professor Haldeman was actively interested in education, and occupied professorial chairs during a large part of his life. He was chosen Professor of Zoölogy in the Franklin Institute in 1842, and afterward filled the positions of chemist and geologist to the Pennsylvania State Agricultural Society in 1852; Professor of Natural History in the University of Pennsylvania, 1850 to 1853; professor in the chair of the same name in Delaware College, Newark, 1855 to 1858; and Professor of Comparative Philology in the University of Pennsylvania from 1869 till his death. He regularly attended the meetings of the Pennsylvania State Teachers' Association. Professor Haldeman had in great part been induced to change his studies from zoölogy mainly to linguistics by the failing condition of his eye-sight; in a similar manner an order to take exercise for his health became the occasion of his engaging in the study of archæology in 1875. He proceeded to carry out an intention he had long entertained of digging for aboriginal relics in the Chickies Rock retreat, a shallow cave on his own property. Here he obtained the interesting collection which he presented to the American Philosophical Society, and which he described in a monograph "On the Contents of a Rock Retreat in Southeastern Pennsylvania," published by the society since his death, with fifteen large quarto plates. He also published archæological papers in the "Smithsonian Report" for 1877, in the "American Antiquarian" and "American Naturalist," and through the American Association.

He was a prolific and successful writer on a curious variety of subjects, some of which appear incongruous with each other. The list of his scientific publications prepared by his daughter, Mrs. Eliza Figgelmery, includes ten titles in conchology, twenty-three in entomology, two on arachnidæ, five on crustacea, six on annelides and worms, seven in geology and chemistry, thirty-three in philology, seven in archæology, and twenty-nine miscellaneous publications. Outside of the immediate circle of subjects with which his name is most prominently associated, he published one or two works of literary criticism, an essay on the "Tours of a Chess-Knight," showing how the knight can pass over the whole chess-board, touching each square but once; a collection of "Rhymes of the Poets," by Felix Ago, containing specimens of false rhymes from one hundred and fourteen prominent writers;

and two mock-heroic poems. He was a contributor to Johnson's "Cyclopædia" and an associate editor of the department of comparative philology and linguistics in it; and he left behind him in manuscript two complete philological works; one on "Word-Building," the other on "English Prosody." The diversity of occupation of which this varied bibliography affords evidence was in part a matter of principle with him, for, says Dr. Brinton, "it was his taste and apparently also his theory that a student should not be a specialist, but should devote his mind to different branches, thus securing wider knowledge"; and he once said to Professor Barber, "I never pursue one branch of science more than ten years, but lay it aside and go into new fields." That he was able to acquit himself creditably in everything he undertook, we have the word of Agassiz, who said of him, "That man Haldeman has an idea behind every word he utters." Professor Le Conte has said that "next to his valuable contributions in philology, the most important work of Professor Haldeman was in the direction of descriptive natural history. He was well versed in several branches of zoölogy, and notably in conchology and entomology; in both studies he perceived latent possibilities of future philosophical development which the then imperfect observations rendered impossible to do more than dimly outline. . . . While his contributions in the two branches of zoölogy above mentioned have contributed to their advance in this country, what are to be especially admired are the zeal, the honesty of expression, and the unselfishness with which he did everything he believed to be right, or to be his duty as the occasion dictated. . . . At all times he was an industrious and intelligent laborer, a warm and sympathetic friend, and a thorough hater of pretense and empiricism."

Professor Haldeman was born of Protestant parents, but, not satisfied with the theology that was preached around him, made a study of the evidences of Christianity for himself, and ended by uniting with the Roman Catholic Church, in whose faith he died.

His death took place suddenly on September 15, 1880, a few days after his return from the Boston meeting of the American Association. The immediate cause was heart-disease, following a period of considerable fatigue.

ENTERTAINING VARIETIES.

—— *Charles Darwin* paid a splendid compliment to John Fiske in a letter he wrote him after reading the "Cosmic Philosophy." This is part of what he said: "You must allow me to thank you for the very great interest with which I have at last slowly read the whole of your work. I have long wished to read something about the views of the many great men whose doctrines you give. I never in my life read so lucid an expositor (and therefore thinker) as you are; and I think that I understand nearly the whole, though perhaps less clearly about cosmic theism and causation than other parts. It is hopeless to attempt out of so much to specify what has interested me most, and probably you would not care to hear. It pleased me to find that here and there I had arrived, from my own crude thoughts, at some of the same conclusions with you, though I could seldom or never have given my reasons for such conclusions." It was but natural that Mr. Fiske should feel that he owed something to the memory of his departed friend for this beautiful tribute to his own labors, and he has well repaid it in his article upon Charles Darwin in the June "Atlantic Monthly." This paper is not only a cordial and highly appreciative eulogy of the character of the great naturalist, but it is probably the most "lucid exposition" that has yet been given of the special doctrines that will in future be associated with the eminent name of Darwin.

—— *The Word of a Khan.*—Hulaku, the grandson of the great Genghis Khan, exceeded even the first Caliphs in religious respect for the sanctity of his word, and it is said that he invariably refused to make a promise "till the possibility of fulfilling it became absolutely indubitable." In the winter of 1257 he laid siege to the city of Bagdad, and, after planting his battering-rams, demanded an unconditional surrender, with the threat that both the Caliph and his subjects would be made to repent it if the gates were not opened before night. The defenders hesitated, but on the following day the Tartars erected a lofty gallows-tree, and the frightened Caliph preferred to come to terms. The magnificence of his gifts seemed to soften the heart of the conqueror, for the ominous scaffold was removed; but, after a private consultation with his captains, Hulaku concluded that, after all, something or other must be done to redeem his word. So, after enjoying the hospitality of the Caliph for a day or two, they marched him to headquarters, and, instead of hanging him, sewed him up in a leathern bag and dragged him across-lots till "every joint and bone in his body was pounded as in a mortar"; and, instead of burning the inhabitants with their city, they brained *eight hundred thousand* of them, and flung them into the Tigris, till the river was actually choked with corpses. Andrew Crichton ("History of Arabia," vol. ii, p. 45) adds that the number of the slain did not even include the victims of the neighboring villages!

—— *Happiness.*—"Happiness," says Leibnitz, "results from the attainment of any greatly desired or greatly needed object."—"Happiness is health," says Helvetius.—"And luck," adds Diderot.—The harmonious development of our mental and physical faculties: Spurzheim.—Peace with God: Eckart.—*Nil admirari:* Horace.—Moral freedom: Campanella.—Victory: Simonides.—A cheerful disposition: Pestalozzi.—Self-approval: Fichte.—The enjoyment of

harmless pleasures and abstinence from injurious ones: Epicurus.—Self-improvement: Hobbes.—An income of five thousand pounds: Richard Porson.—Success: Bolingbroke.—The citizenship of an illustrious state: Sophocles.—Health, books, and solitude: Zimmermann.—Health, wealth, and a liberal education: D'Alembert.—Day-dreams for those who still hope; resignation and a padded easy-chair for those who know better: Schopenhauer.—Visions of glory before the battle of life; a comfortable lazaretto after the inevitable thrashing: Id.—Virtue and resignation: Seneca.—Freedom from the tyranny of kings and vices: J. J. Rousseau.—A good bank-account, a good cook, and a good digestion: Edmond About.—Fortitude in adversity, moderation in prosperity: Anaxagoras.—Peace: Buddha.

—— In an article on *English Poetry* the "Quarterly Review" declares that the historic method shows "how the mind and spirit of the English people in each age is reflected in the poetry of that age as it is nowhere else reflected"; and again, "how truly England's poetry has mirrored the historic condition of the several ages which produced it." The "Quarterly" thus illustrates its theory: "No English poet has more historic value than Chaucer, for none more faithfully reflects all the mingled influences that swayed his time. Though belonging by birth to the middle class, Chaucer's sympathies, as those of Shakespeare and of Walter Scott, were with the aristocrats. He soon became a gentleman and a courtier, and saw life from that side." This looks much as if Chaucer's poetic mirror was somewhat warped, and this is still further confirmed by what the "Quarterly" says: "Wide as was Chaucer's genial humanity, he still looked at life through the eyes of the well-to-do, even of the aristocratic class with whom he was so much associated. No one would guess from his poems that he lived in what a modern historian has called 'a time of shame and suffering, such as England had never known; when her conquests were lost, her shores insulted, her fleet sunk, her commerce destroyed, her people exhausted by the long and costly wars with France, and by the ravages of pestilence.' None would guess from his poems that his was the day when the black-death swept off half the population of England, and when the peasant revolt threatened revolution."

—— *The Age of Faith.*—The credulity of the patristic era may be inferred from the superstitions of the so-called philosophers of that age. Celsus, Lucan, and Apuleius, then hailed as morning-stars of rationalism, would now be in danger of a strait-jacket. The elder Pliny has been called the Roman Humboldt, and his "Natural History" a thesaurus of universal knowledge. The value of that treasury may be estimated by the following specimen-bricks: Among the *feræ naturæ* of Africa he mentions a *catoplus*, "an animal found only in Ethiopia. All who behold the eyes of this beast fall dead on the spot. Luckily, the creature has a heavy head, which is always weighed down to the earth. Were it not for this circumstance *it would prove the destruction of the human race.*" "The bodies of whelks and oysters," the Roman Humboldt assures us, "are increased in size and again diminished by the influence of the moon. Certain accurate (!) observers have found out that the entrails of field-mice correspond in number to the days of the moon's age." The flight of ravens, too, is influenced by the changes of the lunar phases, though their observance of certain days *may* be due to a religious sentiment. In the case of barn-yard fowls there is no room for any such doubt. They are religious birds. By way of establishing this point he thinks it sufficient to mention that chickens throw dust over their bodies in the manner observed by the augurs in the week of purification. During the fort-

night of the waning moon the actions of crows and starlings evince a sad disregard of religious duties, but "burying black briony in the four corners of a field will secure it against the ravages of the most impious bird." Need we wonder that the Kiddles of that age could credit the miracles of St. Polycarp?

—— *The Biter bitten.*—"Intellectual presence of mind," says Lavater, "favors the practice of dissimulation, as well as the art of repartee." This latter gift seems to be a characteristic talent of the Semitic race. Al-Mansour, the second Abbasside Caliph, was importuned to commute the sentence of a rebellious governor of Morocco, on the ground that the followers of the rebel revered him as a saint and a prophet. "That's no excuse," said the Caliph, "for, if he is endowed with the gift of prescience, he must have foreseen that I am going to hang him to-morrow."

During the thirteenth and fourteenth centuries the neglected fields of Northern Spain formed a humiliating contrast with the flourishing *huertas* of the Moorish provinces; yet Alfonso IV of Aragon tried to demonstrate the superiority of his countrymen from this very difference. "In our country men handle the sword and clowns the spade," he told the Moorish embassador; "my cavaliers are too proud to meddle with agriculture." "And yet sixty thousand of these hidalgos have condescended to fertilize the fields of Xeres," observed the Morisco.

But, of all biters bitten, the most astonished was, perhaps, the Jesuit Görres, who insulted meek Moses Mendelssohn by the question, "how it came that in all countries of Christendom the Hebrews were dreaded as cheats?" "No wonder," replied the philosopher, with his blandest smile, "since you have all been so amazingly cheated by *one of our people.*"

—— *American Stock-Breeding* is thus magnified by President Francis A. Walker, writing in the "Princeton Review": "The trotting horse we have created, certainly the most useful variety of the equine species, and we have improved that variety in a degree unprecedented in natural history. Two generations ago the trotting of a mile in two minutes forty seconds was so rare as to give rise to a proverbial phrase indicating something extraordinary; it is now a common occurrence. 'But a few years ago,' wrote Professor Brewer, in 1876, 'the speed of a mile in 2·30 was unheard of; now, perhaps, five or six hundred horses are known to have trotted a mile in that time.' The number is to-day, perhaps, nearer one thousand than five hundred. Steadily onward have American horse-raisers pressed the limit of mile-speed, till, within the last three seasons, the amazing figures 2·10 have been reached by one trotter and closely approached by another."

—— About 1800 we began to import, in considerable numbers, the favorite English cattle, the short-horn. The first American short-horn herd-book was published in 1846. In 1873 a sale of short-horn cattle took place in Western New York, at which a herd of 109 head were sold for a total sum of $382,000—one animal, a cow, bringing $40,600; another, a calf five months old, $27,000; both for the English market. To-day Devons and short-horns are freely exported from New York and Boston to England, to improve the native stock.

—— The Society of Dilettanti was formed one hundred and fifty years ago, by a number of gentlemen who had traveled in Italy and enjoyed its treasures of antiquity and art, for social intercourse and æsthetic improvement. Englishmen most distinguished in politics and literature have been among its members. Originally it was indispensable that a candidate for admission should have been

met in Italy by the member proposing him. This rule is said to have led on one occasion to a resolution of the members which might well astonish geographers. A candidate had been elected on the strength of his having been met at Avignon —at that time really more Italian than French in all its associations. The mistake was seen, and in order to maintain the validity of the election a special resolution was carried, that "in the opinion of this society Avignon is in Italy." It was then considered that a dangerous precedent might have been created, and forthwith a second resolution was passed, that "in the opinion of this society Avignon is the only town in France which is in Italy."

—— *Christian Liberality.*—President Arthur being on Long Island the other Sunday with some publicans and sinners, and the party being an hungered while the corn was not eared, plucked the contents of a trout-pond and did eat. Whereupon the Scribes and Pharisees are shocked at this desecration of the Sabbath-day. The "Christian Union," in an article suffused with complacency at its well-known Christian liberality, remarks: "The country can afford to have a mistaken public policy maintained through four years of misadministration better than it can afford to have a bad example of Sabbath-breaking, impiety, and vulgarity, set before the whole community by men of the first eminence."

—— *Ownership and Rental.*—Of the 3,800,000 farms, approximately, into which the cultivated area of the United States is divided, sixty, or even seventy, per cent are cultivated by their owners. In the Northern States the proportion rises to eighty per cent, or even higher. Connecticut, Maine, and Massachusetts, of the New England States, and Wisconsin, Michigan, and Minnesota, of the Northwestern States, show an excess of ninety per cent.

—— The bigotry of the orthodox Russians, like that of the conservative Spaniards, is a sort of mental disease, but there is less method and more humor in the madness of the Muscovites; a facetious answer has often propitiated the wrath of their clerical inquisitors. The Synod of Moscow once arraigned the philosopher Lermontoff on the charge of being an abettor of the Copernican heresies, especially of the "doctrine of plural worlds," and requested him to explain his paradogmas. "From the bugs in the beard of your Eminence," Lermontoff addressed the "grand metropolitan," "I infer that the beards of the worshipful coadjutors are similarly infested, and by a parity of reasoning the population of this earth inclines me to suspect a plurality of inhabited planets." They let him go.

General Skobeleff, in his memoirs of the Turkish campaign, tells an equally good story at the expense of his orthodox countrymen. When the vanguard of his cavalry approached the hamlet of Kerzanlik, in the eastern Balkan, the frightened burghers sent out a deputation of prominent citizens to implore the clemency of the conqueror. Skobeleff returned an evasive reply, and, after a private consultation with his colleagues, the spokesman of the committee repeated his appeal with the following amendment: that, rather than have their town pillaged, the citizens would agree to supply every trooper of his command with sixteen pints of *slibovitz* (plum-brandy), and consent to believe *in any number of gods not exceeding two dozen!*

CORRESPONDENCE.

VIBRATION OF ROCKS.

Messrs. Editors.

REFERRING to Dr. Garretson's communication in the February number of "The Popular Science Monthly," relating to rock-vibration in the Patapsco Valley, I would state that a like phenomenon has often been manifested at Cuyahoga Falls, Ohio, and has been the subject of much curious speculation on the part of the inhabitants of that village. It has been supposed that the vibrations were caused by the water flowing over the river-dams, but the mystery has been, why the effect should be produced at such great and irregular intervals. Sometimes the vibrations do not occur with noticeable force within intervals of less than one or more years, and yet the quantity of water flowing over the dam increases and diminishes almost continually within its maximum and minimum limits. When the rock-vibrations occur they produce an intermittent rattling of loose window-sashes and jarring of buildings. The Cuyahoga River, which runs through the village, is about fifty or sixty feet wide at the first dam. The height of the dam may be twelve feet. The back water extends about two miles, the banks being sloping and of moderate height. Below the first dam the river runs through a rapidly descending rocky gorge, there being four or five dams within a distance of about half a mile. W. F. H.

Cuyahoga Falls, Ohio, *February* 19, 1882.

DEFINITIONS OF MATTER AND FORCE.

Messrs. Editors.

I write to ask whether the following definitions, distinguishing the three states of matter, have ever been given to the public. I have not found them in any text-book. Also, whether the test given herewith, distinguishing the two kinds of forces, has ever been formally stated in any scientific work. If not, I think it would be well that they should both appear in "The Popular Science Monthly." I submit them to your consideration: *Definitions distinguishing the three states of matter.*—A solid is matter whose cohesion is greater than gravity upon its particles. A liquid is matter whose gravity is greater than the cohesion of its particles. A gas is matter, the repellent force (or heat) of whose particles is greater than gravity and cohesion combined. *Test distinguishing the two kinds of force.*—All forces are divided into two kinds, attractive forces and motive forces, or attractions and motions, and may thus be distinguished: All motive forces can be insulated; no attractive force can be insulated. Had this test been understood in the days of Newton, it might have saved the scientific world immense experimental labor.

Respectfully,

E. H. Randle.

Ripley, Tennessee, *May* 2, 1882.

EDITOR'S TABLE.

SPENCER'S DESCRIPTIVE SOCIOLOGY.

THERE are many who will regret to learn that this great work has been brought to a close. It has not been carried as far as its projector originally intended, but still we can not say that it has stopped prematurely or remains merely as a fragment. On the contrary, it is substantially accomplished. It was a large enterprise, broadly conceived by Spencer twenty-five years ago, as a comprehensive basis on which to build the superstructure of sociological principles. The undertaking involved a carefully digested method of collecting and classifying all the main orders of facts which represent the constitution and characteristics of different human societies, in a form suitable for convenient reference and ready comparison; and it was on a scale that implied the co-operation of several scholars working through many years to execute it. It was inevitable that this task should be of gigantic proportions and involve enormous labor, because social generalizations, to have value, must be based upon that which is both

common and peculiar to many and diverse communities.

The enterprise was, moreover, wholly new, nothing having been previously done toward gathering the multitudinous data necessary for studying what may be called the natural history of human societies. It was also desirable that the work should at first be so effectually done that it could be made popularly available; and, in securing this object, the magnitude of the effort expended upon it by the editor and the compilers simply represented so much labor saved by the student of social questions. Its preparation was not only an elaborate process of condensation and simplification, but it involved a selection of valuable data to be of permanent use in subsequent social inductions and constructions. An incalculable amount of material had to be overhauled to find the pertinent facts. It was a winnowing of the bulky chaff of history to separate its wheat. Science applied to history gives us first of all a revaluation of its materials. The great mass of it must be left out as comparatively worthless. As Professor J. R. Seeley well remarks: "History is now a department of serious scientific investigation. We study history now in the hope of giving more precision, definiteness, and solidity to the principles of political science." And it may be added that we are beginning to study history with a view of obtaining clearer, truer, and broader ideas of the constitution and development of human society.

It is unnecessary here to expatiate on the value of Spencer's method in this undertaking, or the thoroughness of its execution. The original plan, though not technically completed, has been carried out on a comprehensive scale. Three great groups of human communities have been treated, viz.: 1. Savage and Uncivilized Societies; 2. Civilized Societies, Extinct or Decayed; and, 3. Civilized Societies, Historic and still Flourishing. Of these groups, representing communities of every type and grade, past and present, stationary and progressive, the social constitution and history of seventy-two distinct communities are systematically described.

This is done in eight large folio parts or separate treatises, in which the facts are first brought into relation by tabular arrangements, and then the authorities for all the statements are given in an appended form as extracts from the works consulted. The simplification is remarkable; and the command given over the immense details of the whole subject is something quite incredible to those unacquainted with the work.

We are therefore justified in saying that Spencer's "Descriptive Sociology" is nothing less than a cyclopædia of social data, inexhaustible in its wealth of instructive facts, lucid in method, elaborately fortified in its authorities, free from all hypothesis, and furnishing in a very accessible form the kind of knowledge most demanded by the modern student of social affairs.

It would seem that such a work ought to have been welcomed and liberally sustained by a public-spirited age. But it has been commercially a disastrous failure. The obvious reason is, that there is but very little appreciation of the need of such a work. Neither our so-called "Schools of Political Science" nor our so-called "Associations for the Promotion of Social Science" seem to have any idea of what science means in relation to social phenomena. The solitary cultivators of the science are without backing by any parties, societies, or schools, and are left to their unaided exertions. Mr. Spencer could find no publisher to take the pecuniary risk of his enterprise, and so he printed his costly cyclopædia at his own expense. He contributed his talent and his time, paid his assistants and his printer's bills, but he made a work that was not wanted and would not sell, and

he has had to take the penalty in very serious losses. With Part 8, devoted to French Sociology, he issues the following notice of the cessation of the work:

> With the issue of the eighth part, herewith, the publication of the "Descriptive Sociology" will be closed.
>
> The collecting, classifying, and abstracting of the materials contained in the parts now completed was commenced in 1867; and the work, carried on at first by one compiler, subsequently by two, and for some years by three, has continued down to the present time.
>
> On going through his accounts, Mr. Spencer finds that during the fourteen years which have elapsed since the undertaking was commenced, the payments to compilers, added to the costs of printing, etc., have amounted to £4,425 15*s.* 7*d.*, while up to the present time the returns (including those from America) have been £1,054 12*s.* 1*d.*—returns which, when they have been increased by the amount derived from the first sales of the part now issued, will leave a deficit of about £3,250.
>
> Even had there been shown considerable appreciation of the work, it would still have been out of the question to continue it in face of the fact that, after the small sales which immediately follow publication, the returns, so far from promising to repay expenses in course of time, do not even yield five per cent interest on the capital sunk.
>
> Should the day ever come when the love for the personalities of history is less and the desire for its instructive facts greater, those who occupy themselves in picking out the gold from the dross will, perhaps, be able to publish their results without inflicting on themselves losses too grievous to be borne—nay, may possibly receive some thanks for their pains.

The personality of this announcement makes some corrections here appropriate. It has been often said that the profits of Mr. Spencer's American reprints have been greater than those of the original English publications. This is a mistake. Some of his books sold better in this country at first, but the English sales have had a steady increase, so that the income from them has been greater than from the American editions. In regard to the "Descriptive Sociology," although encouraged by his American friends to expect fair returns from it here, the sales have been so small that the publishers declined to reproduce it after the third number, and the work has been kept in stock by the help of others and by advances from Mr. Spencer himself. The appearance of the above notice of discontinuance has, moreover, been the occasion of no little misrepresentation, both in England and in this country. In England it was rumored that Mr. Spencer's losses from publication have been so great as to compel him to go to America to recruit his means by lecturing; and in this country the newspapers have intimated that the failure of his "French Sociology" has brought him to actual want. These statements are wholly groundless. Mr. Spencer has never for a moment entertained the idea of lecturing here, although offered very liberal terms; and, while he is not a rich man, he is by no means in straitened circumstances. He could, of course, ill afford to lose sixteen thousand dollars, besides many years of labor, on a single publication, but it has certainly not made him a bankrupt.

It must be added that Mr. Spencer has never accepted a farthing from any source contributed for his private or personal benefit. When his "System of Philosophy," which was not self-sustaining, was threatened with suspension, some funds were sent him from this country to meet the expenses of its continuance, but they were accepted solely as a public trust, and to be applied to an object recognized by all as of a purely public nature.

ELECTRIC STORAGE-BATTERIES.

SINCE the first announcement of M. Faure's improvement of the Planté secondary battery, speculation has been rife as to the great number and kinds of uses to which such batteries could be applied; and, while much of it has been only sober prediction, some of it has been altogether fanciful. The re-

cent arrival of the steamship Labrador with a number of these batteries on board, which had been successfully used during the passage in electric illumination, has revived both the interest and the speculations about them in this country, so that a few words on their possibilities, and what has been so far accomplished, may be here appropriate. It is hardly necessary to say anything regarding the construction of the Faure cell, as it was fully described in the August number of the "Monthly" of last year, and has since received much attention in the technical papers and by the daily press.

That a thoroughly commercial storage-battery has a wide field of usefulness before it there can be no question. Of the many uses to which it could be applied, one of the most important, perhaps, is as an element in a system of electric distribution for both light and power purposes. With a storage-battery in each house, a smaller electric producing plant in continuous operation could take the place of the larger one required without it, and distribution could be readily accomplished with one set of mains, as, by simply connecting groups of battery-cells in the proper way, arc and incandescent lamps, as well as various pieces of machinery, could be run quite independently of each other.

The power that such a battery confers of utilizing the results of work performed at other times and places makes it peculiarly well adapted for use in isolated electric plant, such as would be suitable for suburban and country houses. Wind and water power are both suitable for charging the battery, but neither of them would commonly be available as direct agents in maintaining a current. It is not at all impossible that we may yet see the farmers using the power of the wind, which costs nothing beyond interest on investment in a mill and repairs, to light their houses, and obtain all the power necessary for many of the operations of the farm.

Such batteries would also have a not unimportant use in the propulsion of cars on street and suburban railways, and it is quite within the bounds of reasonable expectation to think that they could in a good many cases displace steam with advantage on ordinary railways. The conditions requisite to render this feasible are simply good water-power facilities at sufficiently frequent intervals along the line, or such a proximity to coal-mines that the electricity for the charging can be generated at the pit, and coal transportation, therefore, dispensed with. The great advantages of a method of railway propulsion which would dispense with the fire, steam, and smoke of the locomotive, are too obvious to need specifying. Many other applications of these batteries might be named, and the sphere of their utility will doubtless constantly enlarge with the progress of industry.

In order, however, for the storage-battery to take its place as an important element in the growing industrial applications of electricity, it must reach a considerably higher efficiency than it appears to have yet attained. The results obtained in the experiments on the Faure battery at the Conservatoire des Arts-et-Métiers, communicated to the French Academy of Sciences in March last, and which constitute the only trustworthy account yet given of the performance of this battery, certainly leave much to be desired. The experiments were conducted to determine—1. The mechanical labor expended in charging the battery; 2. The quantity of electricity stored up during the charge; 3. The quantity of electricity given out during the charge; and, 4. The electrical work actually effected during the discharge. They resulted in showing that the battery returned forty per cent of the total mechanical power spent in charging it, and sixty per cent of the

electrical work spent upon it. The latter result is alone to the point, as in the former the efficiency of the dynamo-machine enters as an element, as well as that of the storage-battery. On this showing the storage-battery does not seem to have reached a commercial stage, but that it will do so at no very remote time there is every warrant for believing, when we consider the large amount of attention there is now being given to the subject, and the rapidity with which electric appliances are at present passing out of the experimental into the industrial stage.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES, No. XLI.

Diseases of Memory: An Essay in the Positive Psychology. By Th. Ribot, author of "Heredity: its Phenomena, Laws, Causes, and Consequences," "English Psychology," etc. Translated from the French by William Huntington Smith. D. Appleton & Co. Pp. 209. Price, $1.50.

From both a scientific and a practical point of view this monograph is among the most interesting and valuable that have appeared in the "International Series." It is an able statement of the latest knowledge on a subject which concerns almost everybody. We can here only intimate the author's stand-point in the discussion.

Where are our thoughts when we are not thinking them? Not a ten-thousandth part of the great stock of mental acquisitions which a man possesses is ever in consciousness at any one time. And, of those which in our waking states are ever rapidly emerging and disappearing, only a very small portion are obedient to the will—they exist and are preserved independently of consciousness, and they come and go, to a large extent, by laws deeper than volition.

Where, then, is the great stock of our ideas when we are not aware of them? The common, the pre-scientific answer is, they are in the mind, which is an abstract spiritual container, of which we only know that it is an immaterial essence. This mind is made up of faculties, and memory is one of these faculties, in which the intellectual contents are stored up until called for by voluntary thought. Hamilton speculated vaguely about "mental latency," but where the mental stock is kept was always regarded as a great mystery—in fact, an insoluble mystery which there was no use in working at, because all the mind that concerns us is the mind we know about. Mind was thus bounded by consciousness, and memory, or the recall of ideas, was considered purely as a matter of volition, while this faculty in all men was looked upon as very much the same thing. Dugald Stewart, for example, says of the memory, "that original disparities among men, in this respect, are by no means so immense as they seem to be at first view, and that much is to be ascribed to different habits of attention, and to difference of selection among the various objects and events presented to their curiosity."

But it is obvious enough that nothing can be done with the problem of mental *disease* under this view; and, if we are to inquire concerning "diseases of memory," the first thing is to ascertain what we have to deal with that is capable of being diseased. This, of course, is the corporeal part of our nature, and it implies at once that memory has its organic side. It is the nervous part that registers and conserves our psychical acquisitions, and accordingly Professor Ribot begins his work by the study of nervous structures, properties, and activities, and with the consideration of memory as a biological fact. Memory implies three things: first, an impression, and therefore an organism capable of receiving impressions. The various senses bring, and the nervous centers receive and record, these impressions. The centers, moreover, recombine, reassociate, and elaborate these impressions in the most complex ways. This implies, secondly, a conserving or retaining capacity of the nerve-centers, which answers to the notion of mental storing. Then there is, thirdly, the emergence of these impressions in thought, or conscious recollection. This deliverance in consciousness is a result which we might call incidental, and depends, of course, on the prior conditions of impressibility and conserva-

tion, which are, therefore, of fundamental importance. It is estimated that there are a thousand million cells in the human brain, all bound into a living unity by four or five thousand million nerve-fibrils of amazing tenuity, and this is the grand mechanism of registering, conserving, and elaborating impressions and turning them out as groups and systems of ideas. Consciousness is merely a door through which a small part of these cerebral elaborations emerge. Mind grows as this organism grows; its capacities are at bottom organic capacities, and its diseases are breaks, failures, debilities, and degenerations of the nervous substratum of all psychical operations.

Memory is therefore not the faculty of an abstraction, but a phenomenon of nervous dynamics; and it is dependent upon the soundness, vigor, nutrition, and organic perfection of the nervous structure. It is not one thing, but our memories are innumerable. Investigating the problem from the biological point of view, our author is able to throw light on the many forms of failure to which the control of mental acquisitions is subject. He is, in fact, prepared to announce a law of the decay of memory, which explains the order in which acquirements disappear as the organ of thought declines in force by age or from various other causes. The import of the book is therefore highly practical, for in proportion as we have a correct understanding of the subject shall we be saved from the consequences of erroneous views. The subject is far enough from being cleared up, but this little book gives us more trustworthy knowledge about it than can be found in any preceding treatise upon it.

The Present Religious Crisis. By Augustus Blauvelt. G. P. Putnam's Sons. Pp. 196. Price, $1.

This is not at all a scientific book in the usual sense, but it raises the question in a very emphatic way that is fundamental to all science, namely, the question of liberty of thought. Whatever we may say in regard to the alleged conflict between religion and science, of one thing there can not be the slightest doubt: there is a radical and a desperate conflict between theology and liberty of thought. It is historic, and it is contemporaneous; and, if any doubt its inveteracy, let them read Mr. Blauvelt's book, which may be taken, in one of its aspects, as but a new illustration of the old experience in which religious bigotry is arrayed against free and independent inquiry.

In his preface, Mr. Blauvelt remarks: "When the author says that he was graduated from Rutgers College, at New Brunswick, New Jersey, and also from the Peter Hertzog Theological Seminary connected with the same institution, he has given a sufficient guarantee that his original instruction in divinity was of the most hyper-orthodox description. Nor does he concede that any alumnus of either Alma Mater ever went forth who was, to begin with, a more devout and implicit believer than he was in both the essentials and the non-essentials of the general orthodox theology, and notably that of the Calvinistic order.

"It is needless to assure the reader that, while he was a student at New Brunswick, the author was most securely guarded against all contamination from modern infidelity. He does not remember, for example, that in those days he ever heard so much as the mention of the name of Strauss. At the same time, he does have an indistinct recollection that, in a vague and general way, he was taught at once to dread and to abhor that modern theological monstrosity, namely, German rationalism."

It was not to be expected that an active-minded man like Mr. Blauvelt, when he began to think for himself, would be content to remain in the mental condition induced by the theological seminary. Upon assuming the function of a public religious teacher, he found the necessity of a more thorough equipment for his work than his theological instructors had provided, and he therefore entered upon the systematic study of the traditional theology, from the point of view of modern criticism. The spirit in which he engaged upon the work of biblical and religious research is thus indicated. He says that "the specific purpose with which he originally took up these investigations was to vindicate the traditional Protestant conceptions about the Bible and religion against all the assaults of the modern unbelievers. But from the very outset

he conceived the idea that, to make this vindication of any actual and permanent service to those conceptions, it must itself be actual; it must itself be scientific, it must itself be something decidedly more than merely theological. In other words, whatever inherited conceptions, about either the Bible or religion, he found he could not establish by valid evidence and by legitimate reasoning, he resolutely determined that he would never make the effort to establish either by any such distortion of evidence, or by any such illegitimate reasoning, as he had fortunately come to discover to be only too characteristic of the mediæval apologists."

Pursuing his biblical studies from this independent point of view, Mr. Blauvelt, in the spirit of the liberal scholarship of the time, was led to the formation of opinions widely differing from the orthodox traditions. The general results which he reached are given with their proofs in the first eight chapters of the little volume before us, the subjects of which are: I. The Crisis; II. Dogmatic Theology; III. The Validity of the Biblical Canon; IV. The Inspiration of the Bible; V. The Historical Character of the Gospels; VI. The Religion of the Bible; VII. Religion; VIII. The Religion of Jesus. These chapters are full of information in relation to the work of modern criticism on biblical subjects, and they afford an excellent introduction to the general inquiry, for those who wish to know how the register of theological liberality stands at present.

But the sequel of honest and fearless research proved to be in this case, what it had always been before, repression of free thought. In Chapter IX, Mr. Blauvelt gives us some examples of the treatment extended to religious men who have undertaken to inquire for themselves. He tells us that "when, in 1835, Strauss published the initial volume of his first 'Life of Jesus,' he was occupying the position of a theological instructor at Tübingen, with the most brilliant prospects before him, and beloved and honored of all. But even before the appearance of the second volume he was summarily ejected from his position. As the unparalleled commotion created by his work continued to increase, his own father turned away from him in anger; his early teachers in divinity hastened to disavow all complicity with his opinions, and 'as for the friends and companions of my studies,' says Strauss himself, 'these I had the mortification of seeing exposed to so much suspicion and annoyance for their merely rumored intimacy with me, that it became a point of conscientious duty not to expose them to still greater odium by any public memorial of our friendship."

Again, "The faculty of the Theological Seminary of St. Sulpice were once engaged in preparing their annual examinations, when a young candidate for the deaconship, who had always been noted for his great modesty and studious habits, asked leave to submit a number of questions which perplexed his mind and seemed to depress his religious spirit. Unless they were solved to his satisfaction, he could not hope to enter into holy orders. His earnestness astonished and alarmed the entire faculty. They refused at once to examine questions which to them appeared novel or subversive, and, justly fearing that a neophyte who on the threshold of the priesthood was besieged with such misgivings might become a cause of strife in the Church, they withheld their protection, and bade him depart from the consecrated place. This inquisitive and conscientious student was Joseph Ernest Renan." How he subsequently succeeded in passing with the highest honors his examination for University Professor of Philosophy; how he became Professor of Hebrew, Chaldaic, and Syriac Languages and Literature in the oldest chair of the oldest institution in the land; and how he was howled down by the clerical party so that he could not be even heard on the day of his inauguration; and how this was followed by a governmental decree suspending his course of lectures indefinitely—is now well-known matter of history.

When the volume entitled "Essays and Reviews," containing some independent theological thought, appeared in England, the authorities were besieged to prosecute the writers for heresy; and there was one petition which is said to have contained the signatures of not less than nine thousand clergymen of the Established Church, to promote this end. Bishop Colenso was subsequently

hunted down for his heresies, and Professor Robertson Smith has been very recently dismissed from the professorship of Hebrew, in the Free College of Aberdeen, for the same cause.

In further illustration of this religious hostility to independent thought, it may be stated that the author of the book before us contributed in 1873, to "Scribner's Monthly," a series of papers entitled "Modern Skepticism," which were simply a bold and forcible statement of the present drifts of liberal inquiry regarding theological matters. The periodical was widely and vehemently denounced for printing such discussions, and there were public demands made for a new editorship on penalty of the withdrawal of patronage. Dr. Holland resisted the bigoted crusade, and after a year or two another paper was forwarded to him by Mr. Blauvelt, in continuation of the argument. In reply, Dr. Holland wrote: "Your last article was received, and I have read it to-day. At the conclusion of its perusal, I find myself called upon to make the most important decision that has ever come to me for its making, since I became an editor. I must be frank with you. I believe you are right. I should like to speak your words to the world; but, if I do speak these, it will pretty certainly cost me my connection with the magazine."

So much for freedom of religious thought—American freedom of religious thought—Protestant freedom of religious thought, in the last quarter of the nineteenth century of Christianity! Of course, Mr. Blauvelt himself did not escape the penalties of applying the scientific method to theology. We do not notice the statement in his volume, but if any one will turn to "The Popular Science Monthly," for August, 1877, he will see that the reverend heretic was stripped of his office, turned out of the church, and branded as a "betrayer of his Master." It was a little too late to burn him, but is not that about as far as Christian toleration has yet "progressed"? One thing is evident: if Mr. Blauvelt had been a little more dishonest, had played fast and loose with his conscience, and had not been so anxious about the truth, he could have spent all his days in pious comfort in the bosom of the Church. Ever, and in the nature of things, repression of thought is a bid for hypocrisy.

Egyptian Obelisks. By Henry H. Gorringe. Published by the Author, 32 Waverley Place, New York. Pp. 187, with 41 Plates.

The propriety of regarding as a great achievement the removal of a noble object of the oldest civilization from the place where it has rested for ages, to adorn a modern pleasure-ground among surroundings as different as possible from those among which it has stood, has been criticised by admirers of the antique. The fact that the English, French, Germans, and Italians have also taken obelisks from Egypt may show that they are not innocent, but can not excuse us if the act is, as some believe, a kind of vandalism. The criticisms can not, however, be applied justly to those who removed the obelisk in Central Park, for they did not take it from before the temple at Heliopolis, where Thothmes II set it up, but from the place to which others before them had removed it from there. The offense of removal, if it was an offense, was committed by the Romans nineteen hundred years ago; and they may have been guiltless of actual sin, for they probably found the obelisk already thrown upon the ground. Americans have been guilty of no "despoilment," or removal from among "antique surroundings"; for the most prominent surroundings which Commander Gorringe found about the obelisk at Alexandria "were a railway depot, a new apartment-house, and an Arab fort," and it would have inevitably been destroyed if he had not taken it away. In other respects, a feeling of disgust was aroused by the surroundings, and "something more than curiosity was needed to induce one to approach near enough and remain long enough to examine and appreciate it." The removal of the monument from such a situation as Commander Gorringe describes to one that is fully worthy of it, though un-Egyptian, should be considered an act deserving as much praise as the tact, ingenuity, and engineering skill that were displayed in effecting it with complete success. Readers of the present work will find abundant opportunity to admire these qualities as displayed

by Commander Gorringe, for the difficulties he had to meet, whether proceeding from the tempers of men or the stolidity of natural forces, and the means by which he overcame them, are clearly described and illustrated in the interesting and often amusing narrative that forms the first third of the volume. The account of Commander Gorringe's experiences in getting the great stone afloat and across the ocean is supplemented by descriptions of the methods, also illustrated, by which other obelisks have been transported to Paris, London, and Rome. The rest of the book is mainly historical and archæological. In it are included a review of the "Archæology of the New York Obelisk," its symbolism, translations of the inscriptions on it, and its history; a "a Record of all Egyptian Obelisks," with photographs, and translations of their inscriptions; and "notes on the ancient methods of quarrying, transporting, and erecting obelisks," including all that is known on the subject. The final chapter, arranged by Professor Persifer Frazer, describes the analyses of the materials and metals found with the obelisk, and is illustrated by polariscopic sections of rocks. The work thus combines a narrative of personal adventure and professional achievement, an exhaustive historical and archæological account of Egyptian obelisks, and the results of scientific study, in a setting in which no expense seems to have been spared to make it worthy of the subject, and to leave nothing wanting.

Experimental Researches into the Properties and Motions of Fluids, with Theoretical Deductions therefrom. By W. Ford Stanley. London: E. & F. N. Spon. 1881. Pp. 538. Price, $6.

Having been engaged in an experimental examination of the undulatory theory of light, from which he was obliged to desist on account of failing eye-sight, Mr. Stanley took up this subject, he tells us, from the interest awakened by the previous work, and in the hope of making clear to his own mind certain points left obscure by his previous investigations. It soon, however, appeared to him that "there was yet an immense amount of work to be done in researches in the motions of fluids before theoretical principles of the sciences of hydrodynamics and acoustics could be fixed upon mechanical principles with any great precision," and he consequently entered upon the extended investigations set forth in the present volume. Of the unsatisfactory state of much of the work in this branch of physics the author instances the case of wave-motions on water. The true procedure in this case is to determine the manner in which waves are produced on the surface of water by the action of the wind, and then, as a secondary consideration, to investigate the action of gravity in bringing the surface to equilibrium. The reverse of this order, the author asserts, is usually followed, the question being made a case of the oscillations of fluids through gravitation only, and thus begged, as you have then to assume the wave in existence, while its production is the thing to be accounted for.

The first three chapters, the author states, are speculative, and he puts them forth simply as helping to a clearer conception of the nature of a fluid. In the fourth chapter he develops a theory of rolling contact of fluids moving upon static bodies; and in the fifth and sixth chapters he offers principles of conic resistance in fluids which give simple mechanical laws for the class of motions known as vortices, eddies, and cyclones. The eighth chapter is devoted to an exposition of the "principles of motive resistance to the projection of free solids in extensive fluids," and the ninth to the "diffusion of flowing forces in fluids."

These nine chapters constitute the first section of the work, the principles established in which are applied to the elucidation of the manifold phenomena of natural currents produced by the combined effects of heat, gravitation, and the earth's rotation. In the third and closing section of his work Mr. Stanley takes up the subject of the formation of waves upon the surface of water, on which he reaches conclusions not materially different from those of M. Flangergues and Mr. Scott Russell. A fourth section upon sound-motions in fluids, which should have made a part of the present treatise, the author withholds from publication until he has opportunity to go over the subject again, with the help, which he anticipates

will be considerable, furnished by the discoveries in the telephonic transmission of sound.

Myron Holley; and what He did for Liberty and True Religion. Pp. 328. Boston: Printed for the Author, P. O. Box 109.

The name of the author of this work is not given upon the title-page, but by turning over the leaf we get an explanation of the matter as follows:

"*Copyright secured by Elizur Wright.*"

"A copy of this book, which three leading publishers, though guaranteed against loss, have declined to publish, either with the author's name or without it, will be sent, post-paid, on the receipt of $1.50 addressed to Elizur Wright, Box 109, Boston. Or ten copies will be sent, free of freight, on the receipt of $10.

"If any profit should accrue from the sale, it will all be paid to the descendants of Myron Holley till such time as the State of New York shall have paid the just debt it owes them."

We have to thank the writer of this book for one of the most readable and instructive biographies we have ever read, and for doing justice to the character of a very rare and remarkable man. Myron Holley was born in 1779, and died in 1841. His career, which was thus ended more than forty years ago, belongs to the early part of the century, and we had heard much of his noble work and his manly characteristics, though only in a fragmentary and unsatisfying way, and had often expressed regret that there was no accessible sketch of his life. Now that we have it, it is more apparent than ever how great would have been the loss to the world if the task had remained unperformed.

The character of Mr. Holley has been brought out vividly in this volume in several relations. In the first place, he was one of the most efficient, influential, and indefatigable of the pioneers to which we owe the canal system of the State of New York. No matter how this system may be now regarded, the construction of the Erie Canal was a leading step in the progress of our Western civilization, and full of formidable difficulties from the novelty and magnitude of the project, and the state of the public mind upon the subject. One of the most interesting portions of Mr. Wright's racy and graphic book is the account he gives of the origin and growth of the canal policy, which he found it indispensable to delineate in order to bring out the full import of Mr. Holley's relation to it. He was not only a man of great energy and determination, but of admirable tact, clear judgment, and invincible integrity. He entered into the project with his whole soul, subordinated all personal interests to it, neglecting his own private affairs, under the unwise impression that, when the great public work was done, the State would do him justice. We have no room here for explanations upon this point, and must refer the reader to the pages of Mr. Wright, where it is proved that the State of New York cheated Myron Holley out of more than a hundred thousand dollars, when millions would not have repaid the State for the value of his services in carrying out the canal project.

Myron Holley's name will also be historic in connection with the progress of American ideas by his early and controlling alliance with the anti-slavery movement. He was a pioneer reformer in the days when opposition to slavery meant social execration, and when the North in all its great elements—political, ecclesiastical, collegiate, literary, and social—was on its knees to the South for every vile and venal purpose. It was in the palmy days of Northern poltroonery—when the South was told that she could have anything she wanted, and all she wanted; that she had but to name the terms on which this government might continue, and they should be conceded, and when slavery was rampant and regnant as the supreme interest of the American Republic—that Myron Holley took the lead in founding the Northern Liberty party.

To this history Mr. Wright also adds an interesting account of Holley's independent and advanced religious views, and also his ideas of domestic culture, family interests, the education of children, and the conduct of social life. In all these relations Mr. Holley was a man of great individuality, and freedom from the tyrannical restraints of mere conventionalism. He was a thorough-going reformer when reform was less a vo-

cation than it has since become, and he was always marked for the reasonableness and temperateness of his views, and the ability and power with which they were presented.

Myron Holley was one of the personalities that are not to be forgotten, and we have again to thank Elizur Wright for his painstaking and generous efforts to rescue from forgetfulness a character so worthy to be remembered, and admired, and emulated.

Annual Report of the Connecticut Agricultural-Experiment Station, for 1881. New Haven: Tuttle, Morehouse & Taylor. Pp. 122.

The Station has been occupying borrowed quarters in the Sheffield Scientific School, which were so limited that it has been able to do little else than oversee the analysis of fertilizers. This it does gratuitously when consumers of the fertilizers, for moderate fees when proprietors and sellers, are its customers. It having become necessary to remove the Station, the director suggests it be given a situation where it can test the agricultural value of the fertilizers, and perform other experiments in practical agriculture. The act of Connecticut in establishing the Station has been responded to in other States. New Jersey has a Station in connection with the State Agricultural College at New Brunswick, which enjoys the advantage of a farm. North Carolina has lately furnished its station with excellent accommodations at public expense; and New York is organizing a station at an outlay of $20,000 a year. The report contains very full accounts of analyses and valuation of different kinds of fertilizers, and papers on fodders and feeding-stuffs, with their analyses. Of immediate and practical interest are articles on the feeding of milch-cows, at different dairies and the New Jersey Experimental Station, and on feeding with ensilage.

The Occult World. By A. P. Sinnett. Boston: Colby & Rich. Pp. 172. Price, $1.

The author apparently belongs to the band of Theosophists, and asserts that the wisdom of the ancients survives as what he calls the occult philosophy, and that "it was already a system of knowledge, that had been cultivated in secret and handed down to initiates for ages, before its professors performed experiments in public to impress the popular mind in Egypt and Greece. Adepts of occultism in the present age are capable of performing similar experiments, and of exhibiting results that prove them immeasurably further advanced than modern science in a comprehension of the forces of nature." He claims, also, that these adepts have peculiar knowledge of the mental and spiritual world. He has met this science during his travels in India, and has assumed to describe in this volume his experiences of it, and the knowledge he has gained respecting it. Those who read the book with the expectation of finding anything in it to confirm the high-sounding pretensions declared at the start will be disappointed.

Marriage and Parentage, and the Sanitary and Physiological Laws for the Production of Children of Finer Health and Greater Ability. New York: M. L. Holbrook & Co. Pp. 185.

The doctrine of this book is that "the race might be greatly improved by wiser and more sanitary marriages, and by more physiological parentage"; and the author suggests that, "if the average standard of ability of the race in intellect, in morals, and in physical power were raised one degree during each century, the results could hardly be estimated." The subject deserves discussion in a practical, common-sense manner, and receives it here.

The New Infidelity. By Augustus Radcliffe Grote. New York: G. P. Putnam's Sons. Pp. 161. Price, $1.25.

The author has endeavored to show in this work that there is an essential difference between the religious temper of the Aryan race and the Semitic. "Our villages to-day," he says, "are Aryan settlements in their vital points, not Semitic inclosures; and it is so with our religion—at bottom it is pagan still." He has also tried to show that revealed religion is not directly attacked by the discoveries of Science. "Only Natural Religion"—which is regarded by him as the foundation of paganism—"is now assailed in her own house, by her own children, and with her own weapons. This has come to pass through the further develop-

ment of that race-tendency which seeks in nature for the proof of the existence of God. In Nature, paganism found at first many gods; and our present monotheistic idea (outside of Christianity) seems to be the result of the gradual extinction of the belief in diverse deities, by the process of discovering a single force moving the universe of matter."

An Elementary Treatise on Electricity. By James Clerk Maxwell. Edited by William Garnett. Oxford: Clarendon Press. 1881. Pp. 208. Price, $1.90.

The greater part of this work consists of articles written by the late Professor Maxwell some years before his death, with a view to their ultimate publication as an elementary text-book of the subject. Owing to the labor involved in the editing of the Cavendish papers, they were left in a very incomplete state at the time of his death, but the editor has endeavored to carry out the original purpose, by supplementing them with material taken from Professor Maxwell's larger work, "Electricity and Magnetism." The first two chapters are devoted to an experimental demonstration of the principal facts relating to electric charge considered as a quantity capable of measurement, and the third to electric work and energy. In the fourth chapter the electric field is considered, and Faraday's law of lines of induction forms the subject of the fifth. Some particular cases of electrification are taken up in the sixth chapter, electrical images in the seventh, and condensers in the eighth. The various phenomena of the current form the subject of the ninth and tenth chapters, while the methods of maintaining it are considered in the eleventh. The twelfth chapter is devoted to the measurement of electrical resistance, and the thirteenth and last to electrical resistance of substances.

The Mother's Guide in the Management and Feeding of Infants. By John M. Keating, M. D. Philadelphia: Henry C. Lea's Son & Co. Pp. 118. Price, $1.

The author has endeavored to supply a want which he believes to be daily growing, as the monthly nurses of the last generation, whose knowledge gained by experience gave them a place hardly secondary to that of the doctor, are passing away—the want of a better understanding of the requirements of a new-born babe. A necessity for artificial feeding has been developed; over-luxurious and overheated dwellings have raised the question of proper clothing; and the rapid advancement of science has taught us the value of early treatment to eradicate the tendency to inherited taint. For explaining these matters, the work considers the requirements of the infant, first from birth till the cutting of its first teeth, then during the period of dentition, and finally those of a child after its third year.

Opium-Smoking in America and China. A Study of its Prevalence and Effects, Immediate and Remote, on the Individual and the Nation. By H. H. Kane, M. D. New York: G. P. Putnam's Sons. Pp. 156. Price, $1.

"That opium-smoking," says the author of this work, "is a vice that imperatively demands careful study at the hands of Americans is made manifest by the fact that the practice, comparatively unknown among us six years ago, is now indulged in by some six thousand of our countrymen, male and female, whose ranks are being daily recruited; . . . that large and small towns in the West and large cities in the East abound in places where this drug is sold and smoked"; and that in some of the States it has been found necessary to enact repressive laws on the subject. Dr. Kane has made careful investigations of the methods and effects of opium-smoking, by personal experiment, by the observation of smokers in the act and afterward, by correspondence and communication with other similar observers, and by the consultation of books in which the subject is discussed, and communicates the results in this volume.

A Study of the Various Sources of Sugar: Sugar-Cane, Sorghums, Sugar-Beet, Maple, Water-Melons, etc. By Lewis S. Ware. Philadelphia: Henry Carey Baird & Co. Pp. 66. Price, 50 cents.

The author suggests that sugar, being the largest single article of import into the country, offers a greater field for usefulness in the investigation and introduction and development of a new industry than "any

not now here existing." He reviews all the products from which sugar is obtained or is expected to be obtained, in order to discover which one presents the most hopeful opening for enterprise. His conclusions are, that sorghum offers a difficult problem from a financial point of view; that amber-cane is a little more satisfactory, but not satisfactory enough; that the cultivation of corn-stalks for sugar would exhaust the soil; that sugar-cane can not supply the home demand; that the maple can do this no better; that the expectation of obtaining sugar from sweet-potatoes is delusive, and that of getting it from white potatoes more so. Water-melons deserve more consideration, but they are declared to be inferior to the sugar-beet; and the last is pronounced "the only possible plant which can supply the North with sugar." The question remains, whether beet-sugar can be made profitably without the artificial stimulus of protection. If not, we had better continue to raise what we can derive a profit from without artificial aid, and buy our sugar where we can get it cheapest.

Vaccination: Arguments Pro and Con; with a Chapter on the Hygiene of Small-pox. By Joseph F. Edwards, M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 80. Price, 50 cents.

The energy of the opposition manifested by a considerable number of persons against vaccination has induced the author to make his own independent study of the question. He has gathered information from all available sources and considered the arguments on both sides, as he presents them here, and has become convinced that in vaccination properly performed, and in that only, we can find immunity from small-pox. He attaches much importance to anticipating the opposition that may arise and spread in this country, as it has done in England.

First Aid to the Injured. By Peter Shepherd, M. D. Revised and added to by Bowditch Morton, M. D. New York: G. P. Putnam's Sons. Pp. 88. Price, 50 cents.

A brief manual intended for non-professional readers, the object of which is to furnish a few plain rules to enable any one to act in cases of injury or sudden illness, pending the arrival of professional help. The revisions and additions by the American editor have been simply such as would make the work more suitable to this country.

Sir John Lubbock's charming little book on "Ants and Bees" will be the next volume of the "International Scientific Series," and is now in press, to be very shortly issued. It will contain much new, fresh, and entertaining matter on a subject always full of interest. Sir John has been many years a close observer of the habits of these little creatures, and his volume will therefore not be a second-hand compilation, but an original contribution to the most romantic aspect of natural history.

The entertaining sketches entitled "The Mountains of the Moon"; or, Chronicles of Hakim Ben Sheytan, concerning a curious African people, of which we have printed some representative installments in the "Monthly," is now being copiously illustrated for separate publication in a volume.

PUBLICATIONS RECEIVED.

Circulars of Information of the Bureau of Education. No. 6. 1881. Effects of Student Life on the Eye-sight. By A. W. Calhoun, M. D. And No. 1. 1882. Training-Schools for Nurses. Washington: Government Printing-Office.

Fungi injurious to Vegetation. With Remedies. By Dr. Byron D. Halstead. Pp. 35.

The Opium-Habit. By E. H. M. Sill, M. D. New York: Bermingham & Co. 1882. Pp. 8.

On the Trachyte of Marblehead Neck, Massachusetts. By M. E. Wadsworth, Ph. D. Pp. 7.

Biogen: A Speculation on the Origin and Nature of Life. By Dr. Elliott Coues. Washington: Judd & Detweiler. 1882. Pp. 27.

The Death-Rate of Memphis. By George E. Waring, Jr. 1882. Pp. 6.

How the Great Prevailing Winds and Ocean Currents are produced. By C. A. M. Taber. Boston: A. Williams & Co. 1882. Pp. 82. 40 cents.

History and Description of the Luray Cave. By S. Z. Ammen, A. M. Baltimore: J. W. Borst & Co. 1882. Pp. 48. Illustrated.

Educational Journalism. By C. W. Bardeen. Syracuse: C. W. Bardeen, Publisher. 1881. Pp. 30.

Bulletin of the United States National Museum. No. II. Bibliography of the Fishes of the Pacific Coast to the End of 1879. By Theodore Gill. Washington: Government Printing-Office. 1882.

Notes on Physiological Optics. By W. Le Conte Stevens. 1882. Pp. 28.

Current Fallacies about Vaccination. A Letter to Dr. Carpenter. By Dr. P. A. Taylor, M. P. London: E. W. Allen. 1881. Pp. 37.

Journal of the American Chemical Society. Vol. IV, Nos. 1–4. January–April, 1882. New York: Bermingham & Co. 1822. Pp. 48.

How we See. By Dr. Swan M. Burnett. Washington: Judd & Detweiler. 1882. Pp. 25. 10 cents.

The Mental Status of Guiteau. By Walter Channing, M.D. Cambridge, Massachusetts: Riverside Press. 1882. Pp. 22.

The Mineral-Water Controversy, Artificial or Natural. By Carl H. Schultz. New York: Wells, Lockett & Rankin. 1882. Pp. 32.

Forest-Tree Culture in California. Pp. 12. And, On the Growth of Certain California Forest-Trees and the Meteorological Inferences suggested thereby. Pp. 8. By Robert E. C. Stearns. Berkeley, California.

Color-Names, Color-Blindness, and the Education of the Color-Sense in our Schools. By B. Joy Jeffries, M.D. Boston: L. Prang & Co. 1882. Pp. 11.

A Bibliography of Fossil Insects. By Samuel H. Scudder. Cambridge, Massachusetts: University Press. 1882. Pp. 47.

Tenth Annual Report of the Board of Directors of the Zoölogical Society of Philadelphia. Philadelphia. 1882. Pp. 30. Illustrated.

Third Annual Report of the Executive Committee of the Archæological Institute of America, etc., etc. Cambridge: John Wilson & Son. 1882. Pp. 56.

The Domain of Physiology, or Nature in Thought and Language. By T. Sterry Hunt, F.R.S. Boston: S. E. Cassino. 1882. Pp. 27.

The Passion Tragedies of the Nineteenth Century. By Richard Monsill. Rock Island, Illinois. 1882. Pp. 83. 50 cents.

Kindergarten Manuals. Primary Helps. By W. N. Hailmann, A.M. Syracuse: C. W. Bardeen. 1882. Pp. 29. Fifteen full-page Plates. 75 cents.

Capital and Population. By Frederick B. Hawley. New York: D. Appleton & Co. 1882. Pp. 267. $1.50.

Gypsies. By Dio Lewis. New York: M. L. Holbrook & Co. 1882. Pp. 214. Illustrated.

A Compendious Dictionary of the French Language. By Gustave Masson. New York: Macmillan & Co. 1882. Pp. 416. $1.

Cornell University Register. 1881–1882. Ithaca, New York. Pp. 120.

Currency; or, The Fundamental Principles of Monetary Science. By Hugh B. Willson. New York: G. P. Putnam Sons. 1882. Pp. 309. $1.50.

Handbook of Invertebrate Zoölogy. By W. K. Brooks, Ph.D. Boston: S. E. Cassino. 1882. Pp. 392. Illustrated. $3.

An Etymological Dictionary of the English Language. By Rev. Walter W. Skeat. New York: Macmillan & Co. 1882. Pp. 799. $2.50.

Annual Report of the Board of Regents of the Smithsonian Institution, for the Year 1880. Washington: Government Printing-Office. 1881. Pp. 772.

Essays in Jurisprudence and Ethics. By Frederick Pollock, M.A. London: Macmillan & Co. 1882. Pp. 383. $3.

Tenth Census of the United States. Statistics of the Population of the United States by States, Counties, and Minor Civil Divisions. Compiled by Francis A. Walker. Pp. 375. Statistics of Public Indebtedness, embracing the Funded and Unfunded Debts of the United States and the Several States. Compiled under the Direction of Robert P. Porter. Pp. 667.

History and Present Condition of New Orleans, Louisiana, and Report on the City of Austin, Texas. By George E. Waring, Jr., and George W. Cable. Pp. 99.

POPULAR MISCELLANY.

American Forestry.—An American Congress of Forestry was held in Cincinnati, beginning April 25th, of which the Hon. George B. Loring, Commissioner of Agriculture of the United States, was chosen President for the year. Ten State and Provincial organizations, one of which embraces the Canadian Provinces, were recognized, and sections were constituted, as follows: A. Uses of Forests; Dr. Franklin B. Hough, President. B. Conservation of Forests; Dr. John A. Warder, President. C. Influences of Forests, Injurious and Beneficial; Professor William Saunders, President. D. Educational Means; Professor N. P. Egleston, President. Professor William Saunders, of London, Ontario, read a paper on "Insects affecting Forest-Trees," in which he considered the various means of preventing and remedying insect depredations. Dr. George Vasey, of Washington, D. C., read a paper on "The Distribution of Conifers in the United States," and was followed by a discussion on resonant trees, in which the American cypress was declared to be far superior for musical instruments to any foreign wood. Mr. Hough gave an account of what had been done by the State of New York in the matter of the Adirondack Park, after which resolutions were adopted approving the policy of establishing the park, and recommending the adoption of similar measures by other States. Mr. Verplanck Colvin presented a paper on "The Decay and Preservation from Decay of Wood," in which the merits of several preservative substances were considered. Professor Lane read a paper on "The Importance of Experimental Stations of Forestry," and the Congress recommended the establishment of such stations, to be under the care of the agricultural colleges, with a central station. In a paper on "The Profits of Durable Trees," Dr. A. Furness, of Danville, Indiana, showed that an investment of $50 for one acre of land and $25 for tree-plants had returned him in sixteen years a clear profit over all expenses and taxes of $1,048. Mr. C. David, of Madison, Indiana, read a few notes "On the Natural Growth of Forest-Trees" which had given him in about thirty years, upon an originally bare prairie, a wood of

timber-trees from twelve to sixteen inches in diameter. Dr. F. B. Hough stated that a journal devoted to the interests of forestry would be begun soon, to be edited by himself, and published by Robert Clarke & Co., of Cincinnati. Committees were appointed to report on the importance of experimental forest stations; to suggest a plan for the prevention of the destruction of forests by fire and cattle; to report on the importance and necessity of State commissions of forestry; on forest-culture, and on forestry schools. The next meeting was appointed to be held at Montreal, Canada, August 21st and 22d of this year, two days before the annual meeting of the American Association for the Advancement of Science, when reports from these committees are expected. One of the days of the convention was styled "Arbor Day," and was devoted to the planting of trees in the public squares and Lincoln Park. A large number of the trees were named in honor of public men and distinguished citizens, etc. This, though not of particular practical bearing, tends to awaken interest in a cause that needs such awakening sadly enough.

Sound-Shadows in Water.—Professor John Le Conte has described in the "American Journal of Science" a course of investigations, which he has made with the assistance of his son, on sound-shadows in water. It is probably within the experience of all that more or less perfect sound-shadows are thrown by hills, buildings, piers, and other obstacles, to the transmission of aërial vibrations. Nevertheless, the boundaries of such shadows are so imperfectly defined that they can hardly be compared, except in a general way, with the shadows of light. Many ordinary obstacles are elastic and give passage to a part of the sound, as translucent bodies let a part of the light through; and waves are liable to a diffractive divergence, which proceeds from the secondary waves that originate at the boundaries of the obstacle and are propagated within the geometrical shadow. Lord Rayleigh refers the difference in effect in the case of sound as compared with light to the difference in the proportion of the wave-lengths of the two phenomena to the size of the obstacle. An ordinary obstacle bears an immense ratio to the length of a wave of light, but does not bear a very great ratio to the length of a sound-wave. Hence it follows, from the mathematical theory of undulations, that the waves of sound bend around obstacles, and produce more or less effect within the geometrical shadow, while light-shadows have definite boundaries, and are more sharply defined. These views appear to be confirmed by experiment; for the shadows cast by acute sounds are more distinct than those produced by grave sounds. It is also a significant fact that sound-shadows seem to be more perfect or more sharply defined in water than in air. David Colladon found this to be the case in 1826. Professor Le Conte's son, under his direction, made some experiments in this matter during the removal of Rincon Rock at San Francisco, by blasting with dynamite, in 1874. The shock produced in the water—which was felt at the distance of three hundred feet as a short concussion or click—was followed by a second shock in the air, that was heard. When the observer stood upon the top of a wooden pile, the concussion seemed to come up from the water along the cylinder of wood. A soda-water bottle was let down near a pile about forty feet from the explosive cartridge. Whenever it was left within the geometrical shadow of the pile from the cartridge, it was not hurt by the explosion; whenever it was placed outside of the shadow it was shivered to atoms, and this whether it was filled with water or with air. In other experiments stout glass tubes firmly adjusted to a frame-work supporting them, were let down horizontally so as to lie across the piles. In every case the shock of the explosion shivered the parts of the tube that projected on either side of the posts, and left the part within the shadow uninjured. The boundaries between the broken and the protected parts of the glass were sharply defined. The same effects were produced when the tubes were put twelve feet beyond the pile. Professor Le Conte explains these phenomena by endeavoring to show that the sound-shadows are more distinct in water than in air because the sound-waves are shorter in that medium. The character of the explosion also probably has much to do with the nature of the effect: the

sharp, sudden detonation of nitro-glycerine is calculated to generate shorter waves than a more deliberate explosion. This view is confirmed by the fact that, when an extremely disastrous explosion of nitro-glycerine took place in San Francisco in 1880, a violent concussion was felt in the University buildings, three miles away, while no aërial shock was felt at Professor Joseph Le Conte's house, eight hundred and ninety feet farther off, but within the geometrical shadow of one of the buildings. The sound-wave coming by the air was completely cut off by the acoustical shadow cast by the intervening structure. This would not have been the result in the case of ordinary sounds.

The Salmon-Disease.—Professor Huxley recently read a paper before the Royal Society on the disease which prevails occasionally among the salmon in North America and Siberia, in which he reviewed the results of the commission that was appointed in 1878, when the disease raged in the Solway district, to investigate its nature. The evidence taken before the commissioners leaves no doubt that the malady is to be assigned to the diseases caused by parasitic organisms, and that it is a contagious and infectious disease of the same order as ringworm, the muscardine among silk-worms, and the potato-disease, and is the work of a minute fungus. In fact, the *Saprolegnia* which causes it is an organism closely allied to the *Peronospora*, which is the cause of the potato-disease. One distinction may be marked between them, that the *Peronospora* are parasites depending altogether upon living plants for their support, while the *Saprolegnia* are essentially saprophytes, that is, they ordinarily derive their nourishment from dead animal and vegetable matters, and are only occasionally parasites upon living organisms. The zoöspores of these plants, diffused through the water, germinate and produce a mycelium similar to that from which they started as soon as they reach the healthy skin of a salmon. Professor Huxley experimented in inoculating the bodies of dead house-flies from the diseased salmon-skin, and in a few hours saw the bodies completely taken possession of by the white filaments of the fungus; it was proved to him that the pathogenic *Saprolegnia* of the living salmon may become an ordinary saprogenic *Saprolegnia*, and, *per contra*, that the latter may give rise to the former. Hence the cause of salmon-disease may exist in all waters in which dead insects infested with the *Saprolegnia* are met with. The *Saprolegnia* do not appear to be found on decaying bodies in salt-water. We must, therefore, "look for the origin of the disease to the *Saprolegnia* which infest dead organic bodies in fresh waters. Neither pollution, drought, nor over-stocking, will produce the disease if *Saprolegnia* are absent," although they may favor the conditions on which its spread depends. Professor Huxley also concludes that the chances of infection for a healthy fish entering a river are prodigiously increased by the existence of diseased fish in that river, insomuch as the bulk of *Saprolegnia* on a few diseased fish vastly exceeds that which would exist without them. Hence, "the careful extirpation of every diseased individual is the treatment theoretically indicated; though, in practice, it may not be worth while to adopt that treatment."

Catalogue of Scientific Periodicals.—Dr. H. C. Bolton, of Trinity College, is preparing for the press his long-delayed "Catalogue of Scientific Periodicals," which will appear in the octavo series of the Smithsonian Institution. The catalogue is intended to embrace independent journals of pure and applied science, published in all countries, from 1665 to 1880; so far as possible, minute details will be given concerning changes of title, sequence of series, editorship, and date of publication. The arrangement of titles will be strictly alphabetical, but periodicals having different names at different periods will be grouped together under the heading of the first or earliest title of the series, cross-references being made in all cases. A peculiar feature of the catalogue is presented in synoptical tables containing the dates of publication of each volume of the periodicals named, exhibited by a method slightly modified from the plan originated by Professor James D. Dana, and is described in his "System of Mineralogy" (page 34, foot-note). Only a limited number of the periodicals can be en-

tered in the synoptical tables, as preference is given to those which were published during a long series of years, or were issued very irregularly. The publication of the data contained in these tables was at one time abandoned on account of supposed typographical difficulties, but these have been overcome. The catalogue does not embrace transactions of learned societies, these being found in the admirable "Catalogue of Scientific Serials," by Mr. S. H. Scudder; but it does embrace every branch of applied science, including engineering, architecture, chemical technology, geography, ethnology, agriculture, horticulture, telegraphy, meteorology, etc. More than twenty languages are represented in the work, which it is hoped will be completed before the close of the year.

Sioux Superstitions.—Mr. H. C. Yarrow has communicated to the Anthropological Society of Washington, D. C., some observations by Mr. William E. Everett, a Government scout at Fort Custer, on some superstitions of the live Indians. The Sioux believe that when they die they go directly to the "Great Spirit's Big Village," having to cross a long divide, and perhaps fight the spirits of their dead enemies on the way; for this reason they want their best horses killed with them, and their arms put by their side. Reaching their paradise, they are received by their friends and relatives and escorted to a fine lodge, where they meet their wives and children that have gone before; all their war-horses that have been killed in battle reappear before them; if they have been maimed in war, their missing members immediately return to them; if they have mutilated themselves greatly for some friend or relative, that person comes to them and embraces them, and makes them large presents; and they find themselves encamped amid most delightful surroundings. Their idea of sickness is that a bad spirit of one of their enemies has entered the sick person, and must be driven out by noise; and a great uproar is made, while the invalid is made to inhale the smoke of sweet grasses and herbs to assist in the exorcism. Bad spirits are believed to be sometimes sent back to earth in the shape of some animal, and Indians often fancy that they can talk to their friends under such forms. Mr. Everett once saw Sitting Bull making motions with his hands, and talking to a large wolf, which apparently understood what he said, "for whenever he would make the sign for 'Do you understand?' the wolf would throw up his head and howl." The chief told Mr. Everett that he was making medicine to find where the main herd of buffalo were, and whether it would rain or snow before the hunters got back; and he said the wolf was the spirit of a great hunter, and always gave him warning whenever there was any danger close at hand, and told him where the buffalo were to be found. He also repeated some predictions the wolf had made to him, which seem to have been afterward exactly fulfilled. A remarkable superstition prevails with relation to the white-tailed deer, and is so strong that an Indian can seldom be induced to shoot one of those animals. They believe that the deer embodies the spirit of a woman, who, if it is killed, will appear before them and kill them, or make their life a torture. Mr. Everett is acquainted with several stories of Indians who started out, in spite of the superstition, to hunt the white-tailed deer and did not return, but who were afterward found, by their friends going out to search for them, lying by the side of a dead deer strangled, with the marks of a woman's hand on their throat, and a woman's feet on the ground. One grim story of this character, which he repeats with its particulars, relates to six young men who went out together and shot six deer, and were found strangled, with marks of fingers on their throats, and horrified looks, as if they had seen something awful. A curse was pronounced upon the spot where the tragedy happened, by the oldest man of the tribe, which was said by the Indians to have been fulfilled to the letter.

What are Sun-Spots?—Opinions respecting the nature of the sun-spots vary widely. Secchi thought they were clefts filled with metallic vapors; Weber and Kirchhoff, that they were clouds of smoke; Reis, that they were clouds of vaporized oxyhydrate of iron; and Faye, Zöllner, Gautier, Spiller, and Spörer, that they were a dross formed by a cool-

ing of the sun's fiery matter. None of these theories is fully satisfactory. The hypothesis of clouds of smoke hardly agrees with the immensely high temperature we have to ascribe to every part of the sun's surface, and the supposition of a dross would require a greater degree of cooling than could possibly take place there. Herr Edmund von Ludwighausen Wolff has advanced the theory in "Kosmos" that the spots, instead of being cooler, represent parts of the sun that are vastly hotter than the rest of its body; that is, that they are regions in which all the heat-movements have reached the intensity of the ultra-violet and invisible rays; consequently, they appear dark. Herr Wolff remarks that Secchi's observation that the spots gave out not less but more heat than the rest of the sun's surface, and Fraunhofer's that the forces that produce the spectrum-lines appear to be more active in the spots, and the fact that flashes of light are frequently seen to spring up from the midst of them, are contradictory to all previously received theories, but agree fully with that which he proposes, and are clearly explainable by it.

The Laws of Rain-fall.—Professor E. Loomis has prepared, in aid of his studies of the laws affecting the amount of rain-fall at different places, a graduated table of the average annual rain-fall at more than seven hundred points. Of two hundred and four stations at which the mean exceeds seventy-five inches (rising from this amount to 492·45 inches at Cherapunji, Assam), some are elevated more than two thousand feet above the sea, and nearly all are within one or two hundred miles of elevated mountains. Rain chiefly occurs when the wind from the ocean is blowing toward the mountains, and the extraordinary rain-fall at most of them is probably due to the influence of the mountains, by which the wind is deflected upward to such height that a considerable part of the contained vapor is condensed by the cold of elevation. The cases in which the rain-fall is excessively deficient are, on the other hand, those of places in which nothing exists that may cause an upward current of air. Another cause of deficient rain-fall, frequently exemplified, is the descent of a current of air which has been forced up to a great height and suffered condensation of its vapor, after it has crossed the mountain, by the influence of which it has been raised, when its temperature rises and it becomes dry. Such effects are produced by the Rocky Mountains on the plains east of them and by the Himalayas on the Desert of Gobi; and the operation of these two causes will assist in explaining most of the rainless districts of the globe. Other influences modifying the amount of rain-fall are, the meeting of the northeast and southeast trade-winds, which results in a great rain-belt surrounding the globe; the irregular barometric depressions of the middle latitudes, indicating frequent storms; proximity to the ocean, especially when the prevalent wind comes from the sea; and the projection of capes and headlands into the ocean, which contribute to frequent rains. Uniformity in the direction of the winds throughout the year, such as prevails in the trade-wind regions, obstruction of the free movement of surface-winds by mountains, remoteness from the ocean measured in the direction from which the prevalent wind proceeds, and high latitude, tend to produce a dry climate. These principles do not seem to be fully borne out by the phenomena of rain on either side of the Alleghany Mountains, but we have not yet systematic enough or careful enough observations to enable us to determine what is their real influence. Mount Washington, in New Hampshire, exerts a marked influence. The mean annual precipitation there is seventy-seven inches, while in the surrounding districts it is only forty inches.

Improved Sanitary Condition of London.—The report of the English Registrar-General for 1880 completes the fourth decade of reports since the weekly return of that officer was first published. It shows that the death-rate in London for the year (taking the population of the metropolis as given by the last census) was not more than 21·5 per thousand inhabitants, than which a lower death-rate has been returned in only three of the last forty years. The decade closing with 1880 was one of lower mortality in London than any of the three decennial periods for which trustworthy statistics are available, the rate having been

22·4 for 1880, and having ranged from 23·7 to 24·9 in the three decades from 1841 to 1870, and averaged 23·4 during the whole period. The health of London, which was practically stationary during the thirty years ending with 1870, showed a marked improvement during the following ten years; and it may be estimated that at least 70,000 persons were living within registration in London at the end of the ten years who would have died had the mean death-rate of the preceding thirty years been maintained. Dividing the ten years into two periods of five years, the death-rate appears to have been considerably lower in the later than in the earlier period. These facts afford strong evidence of the efficacy of the sanitary efforts of late years in the face of the increasing density of the population, which has, of course, worked against them. This ascription of improvement to the effect of sanitary measures is justified by the fact that the most marked decrease in mortality is in that from zymotic diseases. The average annual death-rate from fever fell from 0·92 per 1,000 during the first three decades of the forty years to 0·37 per 1,000 in 1871–'80. The rate of infant mortality has not, however, diminished to a corresponding proportion with the mortality from other classes of diseases.

The Aquarides, or July Meteors.—M. Cruls has communicated a notice of the meteors which the earth meets between the 25th and 30th of July, called *Aquarides*, because they appear to radiate from a point near δ Aquarii, of which regular observations have only recently been made under favorable conditions. The possibility of the earth meeting at a point in its orbit one or more currents of asteroids is very admissible. Each of these currents might be defined by its proceeding from distinct centers of emanation which may be determined by the crossing of the trajectories; but, to give a character of certainty to the existence of these centers, the determination should rest upon the definition of an adequate number of trajectories. If the existence of a considerable number of radiant points should be verified by continued observations, the phenomena would lose the character which a few trains isolated and distributed after a certain manner in space would present, and would assume that of an intricacy of asteroidal currents, compelling the admission that the infinite multitude of corpuscles occupies an immense zone analogous to the zodiacal light, and possibly having a certain connection with it. M. Cruls believes without doubt that the zodiacal light extends beyond the orbit of the earth, at least in certain directions; while he was observing the meteors in July, he saw the zodiacal light at one o'clock in the morning distinctly projected upon the zenith, and extending toward the eastern horizon; the earth was at that moment within its limits. Three astronomers and three pupils participated in watching the meteors at Rio, from the 25th to the 30th of July. They counted 2,710 meteors, and estimated that five per cent of the whole number escaped observation. It was manifest to all the observers that ninety per cent of all the paths of the meteors intersected each other in the neighborhood of Fomalhaut. The horary means increased fast from the hours of evening till those of morning, and exhibited a remarkable incandescence near sunrise. This seems to indicate that the swarms of meteors move in an opposite direction to the earth; for in that case, the movement of the earth at sunrise being directed toward that point in the ecliptic which is on the meridian, the meteors would then enter the atmosphere under more favorable conditions of speed than at any other hour of the night.

Piseco Lake-Trout and T Lake Falls.—Piseco Lake, in the Adirondacks, formerly the fishing-grounds of the once famous Piseco Club, was noted in the earlier days of its frequentation for the wonderful catches of trout it afforded. According to the statement of the Rev. Henry L. Ziegenfuss, in "Forest and Stream," an average of less than six men fishing from the club-house at Walton Lodge, for an average of less than nine days annually, succeeded in capturing in nine years—1842 to 1850—more than three tons of trout. The largest trout ever taken from the lake—which was called for distinction the "Emperor"—was caught on the 24th of June, 1842, and weighed twenty-six pounds and eight ounces. Another fish weighed twenty pounds and a quarter, and

measured three feet, less half an inch, in length, and two feet, less half an inch, in circumference. In June, 1847, the president of the club killed a red-fleshed lake-trout that weighed twenty-four pounds, the largest that was ever taken there by trolling. Within eight miles of Lake Piseco is T Lake, whose waters flow down the mountains toward West Canada Creek over a fall of nearly seven hundred feet, into the pool called "Snowstorm's Delight." In midsummer but little water comes down from the lake, but in spring and fall immense volumes thunder over the height with a roar that is heard at Piseco. Many extravagant statements are current respecting the height of the falls, but the matter has been partly settled by the measurements of Colonel J. T. Watson, of Clinton, New York, made in 1876. The swift rapids at the top of the falls are one hundred feet in length; the sharp pitch three hundred and ninety feet, and the almost perpendicular fall below two hundred feet, giving a total of six hundred and ninety feet. The falls are thirty feet wide at the top and three hundred feet at the bottom.

The Teleradiophone.—M. Mercadier, the French electrician, has ingeniously adapted the photophone to telegraphy. When, in working with the photophone, the ray of light striking upon the selenium receiver is eclipsed many times in a second, a continuous hum is produced, and this may be broken up into signals by varying the intervals between the intermissions, so that a kind of Morse alphabet can be played upon the instrument. An arrangement for producing signals of this kind is attached to the transmitting instrument, when the signals are sent along the line to a telephone at the other end. No gain over the ordinary telegraph is realized by such an arrangement, but, by multiplying the number of transmitters at one end and the number of telephones at the other end, it can be made to admit of several different messages being sent along the same wire at a time, and of sending messages at once from opposite ends of the wire without confusion. In order to give the multiple messages effect, it is only necessary to rotate the eclipsing wheels, which act upon the several selenium receivers at different speeds, so as to produce notes of different pitch in the receiving telephones, and to fit each resonator so as to enhance a particular note. Then, although the complex current flows through all the telephones in turn, each telephone will only render to the ear of the clerk the particular note for which he listens, and the makes and breaks of that note will be the message.

Origin of the Astronomical Symbols.—Every one who consults an almanac is acquainted with the curious figures that appear in its pages as symbols for the planets and for celestial phenomena—the only real hieroglyphics which survive in current use to our day—but few, probably, have examined into their origin. Modern text-books on astronomy do not condescend to discuss such matters, but the books of the two former centuries gave full explanations on these as well as on some other points, which the school-room science of to-day is too dignified to consider. Such books were Lalande's "Astronomy," in French; Long's, in English; and Riccioli's "Almagestum Novum," in Latin. Lalande shows that ☿, the symbol of Mercury, is derived from the caduceus, the serpent-wreathed mace of the Greek and Roman divinity; ♀ is a hand-mirror, the most appropriate symbol of Venus, the goddess of beauty; ♂, a lance, nearly covered by a buckler, which it most became the god of war, whose planet, Mars, it represented, to carry; ♃, a capital Greek zeta, the first letter of the name of Zeus, or Jupiter, re-enforced by an intersecting stroke; ♄, the sickle of old Father Time, Chronos, or Saturn; and ☉ and ☽, figures of the disk of the sun and of the new moon. Huet gives the same explanation in his notes on Manilius, and Long gives a series of artistically designed pictures of the objects themselves, from which the figures are derived. The symbols for the sun and moon are very ancient. They occur on the Egyptian monuments, and are mentioned by Clement of Alexandria in the second century. The others are of comparatively modern date, and are not so old even as the Arabian manuscripts. They were invented by the astrologers of the middle ages, and are said by Humboldt to be not older than of

the tenth century. The sign for the earth, ♁, a globe surmounted by a cross, indicating its Christian origin, may be traced to about the sixth century. Of the recently discovered planets, the sign for Uranus, ♅, is a modification of the initial H of Herschel; and that for Neptune, ♆, is derived from the trident of the sea-god. The attempt to give similar symbols to the smaller planets was abandoned after they began to be too numerous to be distinguished in this manner.

Obesity and its Treatment.—According to the observations published by M. de Saint-Germain, in the "Union Médicale," the great danger to be feared from obesity lies in the direction of lesions of the heart. Considerable differences exist relative to the influences of sex on the liability to the affliction, but M. de Saint-Germain believes that women are the more liable to it, and that in proportion as they are addicted to alcoholism, prostitution, or inactivity. It may be developed at any age, even as early as two years; M. Hillairet recently exhibited at the Academy of Medicine a little girl six years old who was wonderfully fat. Among the causes of obesity are mentioned excess of food and of alcoholic drinks, too much sleep, and occasionally marriage. Widowhood, which makes men fat, appears to have the contrary effect on women. M. de Saint-Germain illustrates his method of treatment by citing the example of one of his best friends—who was most probably himself. Having grown to the weight of two hundred and thirty pounds, he tried to train himself down by the regulation method of treatment, and in six weeks lost twenty-nine pounds and all his strength. He then stopped, recovered his weight and his health, and suffered no particular change for eight years. Then he took to horseback-riding, gymnastics, and fencing, varying his exercises occasionally, but always keeping them up actively, in the early morning hours. To these he added a severe regimen; no breakfast after his fatiguing exercises, but a cigar to sooth the stomach. Later a breakfast of two boiled eggs, a cutlet with salad and fruit, coffee without sugar or spirit, no bread or wine, but water or tea without sugar to drink; for dinner, no soup, a plate of meat, a dish of green vegetables, fruit, no bread or wine; no dining in the city; absolute self restraint. The result was a fall of his weight to two hundred and twelve pounds, and increased vigor.

An Ideal Jelly-Fish.

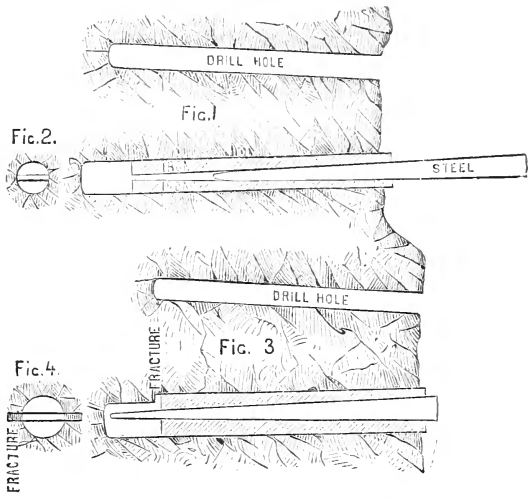
A jelly-fish swam in a tropical sea,
And he said: "This world it consists of ME;
There's nothing above and nothing below
That a jelly-fish ever can possibly know,
Since the highest reach we can boast of, sight,
Is only the vaguest sense of light;
And we've got, for *the final test* of things,
To trust to the news which one feeling
brings.
Now all that I learn from the sense of touch,
Is the fact of *my feelings* viewed as such;
But to think these have an external cause
Is an inference clear against logical laws:
Again, to suppose, as I've hitherto done,
There are other jelly-fish under the sun,
Is a poor assumption that can't be backed
By a jot of proof or a single fact:
In short, like *Fichte*, I very much doubt
If there's anything else at all without;
And so I've come to the plain conclusion,
If the question be only set free from confu-
sion,
That the universe centers solely in me,
And if I were *not* then *nothing* would be!—"
Just then a shark, who was passing by,
Gobbled him up in the twink of an eye,
And he died with a few convulsive twists,
But, somehow—the universe still exists!

GRANT ALLEN.

Reciprocal Parasitism.—M. Maxime Cornu has taken notice of a prolongation of the vegetative activity of the chlorophyl-cells occurring under the influence of a parasite. M. Schwendener has affirmed that lichens are really fungoid parasites on algæ, which they envelop with their filaments and at the expense of which they live; and his view has been confirmed by the investigations of Rees, Bornet, and Stahl. The principal argument which has been opposed to this theory is based on the difficulty of explaining how the alga continues to live, grow, multiply, and even acquire new vigor, instead of perishing in the toils of the parasite. M. Van Tieghem supposes, to explain

this singular circumstance, a special form of parasitism, which he calls reciprocal parasitism. It may, perhaps, be illustrated by the case of the leaf of the maple, which is frequently attacked at the end of the summer by an erysiphus, that occupies the lower surface and fruits there. In the fall the leaves change color and drop off, but the spots occupied by the erysiphus remain green, and so continue, a spot distinct from all the rest of the leaf, for weeks. A similar reciprocation may take place between the algoid and fungoid parts of the lichen.

A Mechanical Rock-Excavator.—By the aid of perforators, worked by compressed air, it has been possible to complete in a few years works of subterranean excavation like the tunnels of Mont Cenis and Mont St. Gothard, which would formerly have occupied several generations of miners. Hand-drilling can be dispensed with when such perforators are used, for the perforator itself makes the hole destined to receive the powder by which the rock is blown up, and the miner has nothing to do but to pick up the pieces. A full solution of the mechanical operation of boring is thus obtained, and a self-acting ventilation of the shafts and the removal of all noxious vapors are secured at the same time. Till recently it was not practicable to apply the perforators in coal-mines charged with explosive gases, for such mines had to be worked without using powder. Two French engineers, MM. Dubois and François, have resolved this difficulty by the construction of an apparatus which they call a *bosseyeuse*, or, as we might call it in English, a pioneer-drill. Its principal feature is a kind of needle-wedge which is made under the action of the perforator to enter the hole made by the drill and break the rocks up by the force of pressure, without throwing out the fragments as powder does. This apparatus has been used in several gas-infected mines in the Belgian coal-basin, with a considerable consequent diminution in the frequency of



FIGS. 1 TO 4.—APPLICATION OF THE PIONEER-NEEDLE TO BREAK UP THE ROCK IN THE HOLE THAT HAS BEEN ALREADY MADE BY THE FOIL OF THE PERFORATOR.

explosions. The powder, if that is used, is introduced when the hole excavated by the perforator has reached a depth of about twenty-seven inches; or, if the mine contains explosive gases, the needle-wedge is substituted for powder. This apparatus, which is represented in the figures (1 to 4), consists of two bars of iron, shaped like segments of a circle, and touching by their ends, the union of which constitutes a cylinder hollowed along its axis with a conical hole. The section of the two segments is of the same size as the drill-hole, so that they fill it completely when inserted in it. As soon as the drill-hole has been hollowed to a sufficient depth, these two bars are in-

serted in it, and a conical steel needle-drill is introduced into the central hole of the metallic cylinder thus formed. The piston-head of the perforator is then made to strike upon the head of the needle, so as to drive it in like a wedge and cause it to force the two segments apart and split the rock. As many holes may be made as are necessary to break the rock up, and this depends much upon its hardness. Fig. 5 represents a sec-

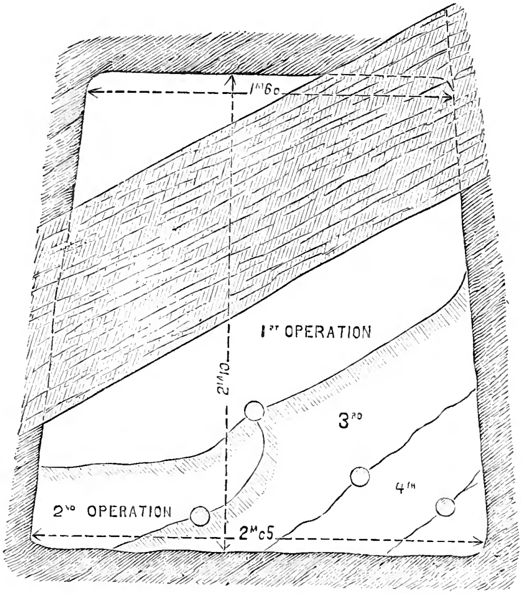


FIG. 5.—SECTION OF A GALLERY UNDER A COAL-MINE, INDICATING THE HOLES TO BE BORED BY THE PERFORATOR, SO AS TO BREAK UP THE STERILE ROCK IN FOUR SUCCESSIVE OPERATIONS.

tion of the chamber of a coal-mine, and indicates the position of the holes that have to be drilled to break up the rock in four successive operations. The inventors of this apparatus claim that rock can be broken up with it in veins of the average thickness almost as fast as with gunpowder.

Transmission of Vibrations.—The Transactions of the Seismological Society of Japan contains an account of experiments by Professor H. M. Paul, in Washington, D. C., on the transmission of vibrations from railroad-trains through the ground. Cups containing mercury were fixed at four stations, at distances of from 0·29 to 0·93 of a mile from the railroad, in which the amount of disturbance caused by vibration was ascertained by noticing the displacements of the reflected image of the pole-star. The character of the effects varied according to the distance of the station from the train, the nature of the ground at the station, and the kind of train, but they were distinct. At one of the stations the communication of vibrations, which were limited to a shallow depth, appeared to be interrupted by the intervention of a ravine. The effect of carriage-driving on a public road was also observed. A hack carrying four persons and drawn by two horses, about four hundred feet away, caused a temporary shaking of the mercury whenever a wheel struck a stone or hollow; and a similar effect was produced while the carriage was crossing a small wooden bridge at about five hundred feet; but no serious continuous disturbance was perceived till the carriage approached within two or three hundred feet of the instrument.

The Systematic Position of the Brachiopoda.—In the "Jenaische Zeitschrift für Naturwissenschaft," Jena, 1881, Dr. Oscar Hertwig and Dr. Richard Hertwig, the eminent embryologists, recognize the work of

Edward S. Morse on the Brachiopoda as follows. Having made certain comparisons, they say: "After these analyses, it is self-evident that the brachiopods must be distinguished from the mollusks, and that the two represent perfectly different types of development. It is the merit of Steenstrup to have first recognized this, and indeed, as early as 1847, to have sought a connection of the brachiopods with the annelids. Independently of him, Morse has pursued the same road, and one may say decided the question by comparing, with great ingenuity and to the minutest details, the anatomy of the brachiopods with that of the worms and the mollusks, and has in this connection proved throughout their difference from the mollusks and agreement with the annelids." Gegenbaur also assumed the position of Steenstrup and Morse, and remarks in the second edition of his "Grundzuge" that the brachiopods have little more in common with the mollusks than the possession of a shell quite different from the housing integument of the latter, and form a small and sharply distinguished division, the origin of which may be traced back to the stem of the worm and specially of the chætopod.

Death of Professor William B. Rogers.—Professor William B. Rogers, ex-President of the Massachusetts Institute of Technology and one of its founders, died very suddenly of apoplexy, May 30th, during the exercises of the graduating class of the institution, which he was attending. He had begun making an address, and was reviewing what the institute had accomplished, when he was attacked. He was taken from the hall, and died in about twenty minutes. Professor Rogers was born in Philadelphia in 1805, and was one of four brothers, all of whom have distinguished themselves in science. He suceeeded his father, Dr. P. K. Rogers, as Professor of Natural Philosophy and Chemistry in William and Mary College, in 1829, and was Professor of Natural Philosophy and Geology in the University of Virginia from 1835 to 1853. He removed to Boston, where he had since lived, in the latter year. He was President of the Institute of Technology from 1862 to 1868, and was President of the American Association for the Advancement of Science in 1875. He was the author of works on the "Strength of Materials" and the "Elements of Mechanical Philosophy," and of many scientific papers. A portrait and sketch of Professor Rogers were given in "The Popular Science Monthly" for September, 1876.

The Mysterious Volcano of Apo.—The Governor of Davao, Mindanao, Philippine Islands, recently ascended a remarkable volcano called Apo. An expedition to the mountain had often been contemplated before, but had been prevented, partly by the unexplored and difficult character of the country, partly by the opposition offered by the natives, who, though nominally Mohammedans, believe that the summit of the mountain is inhabited by a demon to whom they are accustomed to make offerings when they think he is angry with them, or when they wish him to allow them to collect sulphur. The crater of the volcano was found to be 9,970 feet above the sea, extinct, and covered with vegetation within, although the temperature of the air was but little above the freezing-point. A wide chasm on the southern slope of the mountain was the seat of numerous *solfataras*, which, furiously spitting out sulphurous vapors with a fearful smell and roar, might well inspire fear in the minds of an ignorant populace. The Tagalaya stream, which rises on the mountain, and in the rough bed of which the ascent was made, brings down lumps of sulphur. A sharp cold prevails in the crater and on the mountain for three thousand feet below it, but the lava and ashes still radiate enough heat to be perceptible, and make one warm who lies down upon them; and, perhaps, to keep up the vegetation which manages to subsist there. Two petrified tree-trunks, which were noticed during the ascent, indicate that a very different vegetation formerly existed there.

Eggs of Reptiles and Insects as Food.—The eggs, even of animals which impress us most unpleasantly, have their value as food, and seem to be capable of inspiring a relish in the palates of those who have learned to eat them. The eggs of most of the species of tortoises are excellent for eating, nutritious, and agreeable to the taste; and those

of the green turtle are held in great esteem wherever they are found. The mother-turtles lay three times a year, depositing sometimes as many as a hundred eggs at a laying, and carefully covering them up with sand, so that it requires an experienced searcher to detect them. The Indians of the Orinoco and Amazon obtain from these eggs a kind of clear, sweet oil, which they use instead of butter. About five thousand eggs are required to fill one of their jars with oil; yet so abundantly are they deposited that about five thousand jars are put up yearly at the mouth of one of the rivers; the harvest is estimated by the acre. Young eggs are frequently found in the bodies of slain turtles by hundreds, in all stages of development, and generally consisting entirely of yolk; they are often preserved by drying, and are considered a great luxury. Alligators' eggs are esteemed by the natives of the regions where those reptiles abound; and Mr. Joseph, in his "History of Trinidad," says that he found the eggs of the cayman very good. The female alligator lays from one hundred and twenty to one hundred and sixty eggs; they are about as large as the egg of a turkey and have a rough shell filled with a thick albumen. One of the lizards, known as the iguana, is capable of furnishing as many as fourscore eggs, which when boiled are like marrow. The larvæ and nymphæ of ants are considered by many people a choice relish when spread upon bread and butter, and are said to be excellent curried. In Siam they are highly esteemed, and are so valuable as to be within the reach only of the rich. In some parts of Africa, where ants swarm, they are said to form at times a considerable proportion of the food-supply. They are used in some countries of Europe for making formic acid, and are subject to an import duty. The eggs of insects belonging to a group of aquatic beetles are made in Mexico into a kind of bread or cake called *hautle*, which is eaten by the people, and may be found in the markets. They are got by means of bundles of reeds or rushes, which are put in the water and on which they are deposited by the insects. Brantz Mayer, about forty years ago, noticed men on the Lake of Tezcuco collecting the eggs of flies which, he says, when cooked in cakes were not different from fish-spawn, having the same appearance and flavor. "After the frogs of France and the birds' nests of China, I fancy they would be considered delicacies, and I found they were not disdained on the fashionable tables of the capital." According to the report of the Commissioner of Agriculture for 1870, the larvæ of a large fly which frequents Mono Lake, in California, are dried and pulverized and mixed with acorn-meal and baked for bread, or with water and boiled for soup.

Sanitary Inspection of Houses.—Mr. Lewis Angell, Sanitary Inspector of West Ham in Essex, an outlying district of London, says, in illustration of the prevalence of sanitary defects even in the best houses, and of the need of thorough inspection, that in the civic palace of the Lord Mayor of London, "three quarters of an inch of floating fungi scurf was recently found on the surface, and three eighths of an inch of mud at the bottom of the cisterns, while a bottle of water on his lordship's table contained hundreds of nematoid worms." Offensive mud and animal organisms were also found in the cistern of the Athenæum Club, St. James. We habitually defy disease when we leave the doors of our closets open and the windows shut. The reverse ought to be the practice. He believes that sanitary science should be put on a par with literary and mathematical studies in the schools, and that public and official inspection should be provided for everywhere, the expense in the care of new buildings to be met by fees charged upon the owners and builders, who expect to derive a profit from them. He commends what has been done in Chicago in the official inspection of tenements, and the official supervision of plumbing that has recently been adopted in New York.

The Screw-Propeller.—The people of Boulogne, France, have recently set up a statue of Frédéric Sauvage, to whom they ascribe the invention of the screw-propeller. He devised a means of propulsion by screws in 1832, and offered it to the French Government. A commission reported upon it that it might be employed with advantage

for small boats, but would be of no use for large vessels. The English Government tried to buy the invention exclusively for England, but Sauvage refused to sell it on such terms. It was applied to a steamer in 1841, after plans furnished by Sauvage, but the builder and engineer of the vessel took all the credit for it. After an experience in the debtors' prison, and then spending $16,000 in experiments during ten years, Sauvage passed the last years of his unfortunate life in the Picpus asylum. The priority of his invention is disputed in behalf of several Englishmen: of James Watt, who proposed to use a screw in 1770; of Edward Shorter, who patented a propeller in 1800, and applied it two years afterward; of Stevens, in the United States, who tried to drive a boat by a screw in 1804; of Trevithick, who invented a screw-propeller in 1816; and of Samuel Brown, who used one in 1827. F. Pettit Smith, to whom more than any other person we owe the use of this motor, never claimed to be its inventor, but only that he placed it in the dead-wood of the vessel. The "Revue Scientifique" claims the credit of the invention for Charles Dallery, who obtained a patent for a screw-propeller and a tubular boiler in 1803.

NOTES.

The fifth annual meeting of the American Society of Microscopists will be held at Elmira, New York, Tuesday, August 15th, and on the three following days. Liberal arrangements have been made by the local committee for entertainment. A meeting of great interest is anticipated. A larger list of papers than on any previous occasion has been promised, and preparations have been made for a full display of instruments, accessories, and objects. Committee reports are to be made "On Eye-pieces," "On Revision of the Constitution," and "On the Question of a Quarterly Journal." Members intending to be present will please notify Dr. Thaddeus S. Updegraff, secretary of the local society, Elmira, New York; members intending to present papers or communications, to Professor D. S. Kellicott, secretary of the association, 119 Fourteenth Street, Buffalo, New York.

M. A. Blavier has endeavored to account for certain remarkable climatological anomalies that have been recently observed in France, by supposing that the Gulf Stream was deflected from its regular course. He observes that the sardines, which, in their regular migrations, follow exactly the course of the derivative current of the Gulf Stream, called the Rennel, have followed another route than their usual one to the ocean; also that a slight elevation of temperature has been observed in Shetland; and that an accumulation of ice has been noticed at the French station in Iceland.

M. de Lacerda, of the Physiological Laboratory of Rio Janeiro, recommends the permanganate of potash as a sure antidote for the bite of venomous snakes. To be effective the solution of the salt should be prepared at the moment of using it; and in order that it may always be on hand, he recommends that packages be put up to be carried by persons going into dangerous spots, containing one tenth of a gramme of the permanganate, and a ten-gramme bottle. The solution should be injected with a syringe.

From a statement made in the French Academy of Sciences, by M. Gosselin, it appears that M. Collin, of Alfort, has found that American trichinous meat contains almost exclusively dead trichinæ, and is, therefore, not particularly dangerous.

Macgillivray, in his narrative of the voyage of H. M. S. Rattlesnake in 1852, said that he had seen the skulls of children at Cape York pressed into a conical shape by the constant manipulation of their mothers. Von Baer doubted the possibility of such an effect being thus produced. Dr. Miklucho Maclay, however, saw the pressure actually applied by the mothers at Torres Straits in 1880. He says that, during the first weeks of the lives of the children, the mothers were accustomed to spend several hours each day in compressing the heads of their children, for the express purpose of giving them a conical shape. Another kind of deformity, in the heads of the women, resulting from their habits in carrying loads, was observed by Dr. Maclay in New Guinea. The women here were accustomed to put whatever they had to carry into bags, which they supported by bands laid on their heads, a little behind the coronal suture. This practice, pursued from childhood, produced a saddle-shaped depression across the skull, which was sometimes three or four millimetres deep.

Professor E. Desor, of Neufchâtel, Switzerland, geologist and anthropologist, and a student of glaciers and glacial geology, died in March last. He lived several years in the United States, and has left his mark on American geology and marine zoölogy.

The National Academy of Sciences consists of ninety-five members and four honorary members, ninety-nine in all. Thirty-four live in the New England States: seventeen in Massachusetts, three in Rhode Island, and fourteen in Connecticut. Thirty-six live in the Middle States: fifteen in New York, five in New Jersey, fourteen in Pennsylvania, two in Maryland. Sixteen live in the District of Columbia. Nine live West: one in Ohio, one in Kentucky, one in Illinois, two in Missouri, four in California. Three live abroad, all being New-Englanders. One is unclassified as to residence. None live South. Total, ninety-nine.

Forty-three represent the mathematical sciences, as pure mathematics, astronomy, geodesy, engineering, physics, etc. Twelve represent chemistry; sixteen represent the geological sciences; twenty-four represent the biological sciences; four are unclassified. Total, ninety-nine.

M. Paul Bert has been elected a member of the French Academy of Sciences, to fill the vacancy in the department of medicine and surgery caused by the death of M. Bouillaud.

M. Piot has made experiments, under the direction of M. Laborde, to ascertain the order in which the functions of the organized tissues cease in normal asphyxia. He insists that the exact moment of death is very difficult to determine, and that we can not fix the instant when the stoppage of the heart and of respiration is definite. The mechanical movements of inspiration first cease to become apparent; then the beating of the heart becomes less frequent, but continues; the pupils of the eyes are dilated excessively, and the cornea becomes insensible. These, however, are only apparent signs of death, for dogs in which such phenomena have appeared may still be brought back to life by means of artificial respiration.

M. de Khotinsky, a Russian naval officer, has been endeavoring to improve the lime-light so as to render it available for general purposes. He proposes to supply oxygen in a condensed form, and to burn ordinary gas with it in his new lamp, in which he has made a fresh adjustment of the lime or magnesia.

M. Paul Bert, before the resignation of the Gambetta ministry, had instructed M. Dumas, permanent Secretary of the French Academy of Sciences, to draw up a list of scientific men who had died or received injuries while making experiments or researches for the advancement of science, with the view of awarding pensions to the widows and families of those who had died, and of giving substantial aid to those who survived.

M. Campardou has made some new observations on the successful treatment of apparently dead infants with baths at about 120°. In one case, an infant on which friction, inflation of the lungs, and other remedies had been tried in vain, and which M. Campardou regarded as lost, was put into water of 113°, and revived in less than fifteen seconds. The same process was applied to an infant fifteen days old, which had apparently died after a gradual decline.

M. Marey has succeeded in obtaining photographs of birds and insects in the act of flying. He introduces the "photographic revolver" into an apparatus having a shape roughly like that of a gun, and, pointing it at the flying animal as if he were going to shoot it, he has obtained a series of impressions each of which represents a stage of the flight. The pose, which is naturally only about $\frac{1}{1500}$ of a second, has been prolonged to $\frac{1}{700}$ of a second with most satisfactory results.

The French Academy of Sciences recently departed from its custom of giving memorial honors only to members, to pay a tribute of respect to M. Poitevin, deceased who was one of the principal contributors to the improvements in processes for multiplying photographs by which the photographic has been raised to be a real industrial art.

According to Libanius, the term "atheists" was used as a common name for Christians by the cultivated Greeks of his period—the fourth century.

König's great tonometer, the unique collection of standard tuning-forks which was shown at the Philadelphia Exhibition, is still for sale, the project to buy it for the University of Pennsylvania having fallen through. "Nature" suggests that if it can not be acquired for the South Kensington collection, an effort be made to buy it for either the Cavendish or the Clarendon Laboratory.

M. C. Decharme has given an account of hydrodynamic experiments in which he has imitated the phenomena of electro-magnetism and induction by means of liquid currents. M. Bjerkness, in his experiments performed with vibrating and pulsating bodies in still water, obtained analogous effects, but inverse, to those of electricity and magnetism. M. Decharme, using running liquids, found the analogies to be direct. He produced sonorous vibrations of greater or less pitch by turning currents of gas upon mercury, and more or less grave vibrations by directing currents of water upon a solid body. The vibrations of the former kind were carried beyond the highest, and those of the latter kind below the lowest, limit of perceptible sounds.

ADOLF ERIC NORDENSKIÖLD.

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THE PHYSIOLOGY OF EXERCISE.

By EMIL DU BOIS-REYMOND.

II.

BETWEEN the external sensation and the internal perception stands the time-sense, adapted to the distinction and estimation of the succession; it is really a grosser hearing and sight, for the cochlea and retina do nothing more than distinguish the more or less rapid succession of impressions. The time-sense is susceptible of a high degree of training, as may be learned from intercourse with astronomers and watch-makers. The later chronoscopy has warranted the possibility of determining the educability of the nervous system to a punctual obedience. In the experiments which Herr Donders first made tentatively, the mean of the time which the same observer required to execute a determined movement in accordance with some signal which he saw, heard, or perceived, sunk from day to day to a limit which was soon reached. The result was the same in a small degree which the drill-master enjoys in a large degree, when to his command a single sound responds, hardly longer protracted than to twice the difference in the time required for the sound-wave to pass from him to the nearest and to the farthest man.

Finally, the internal sense also, which has already entered into our considerations, is susceptible of exercise. Before all, the memory is strengthened by practice to a certain degree, and according to its employment in different directions. It may be recorded here that, as I have heard Schleiden relate, Robert Brown was able to distinguish twenty-five thousand species, Kunth only twenty thousand species of plants; and, if Kunth undertook to impress more than that number

* An address at the anniversary of the Institute for Military Surgeons, Berlin, August 2, 1881.

upon his mind, others passed out. The morphologist remembers forms, the mathematician formulas, though he may prefer to work them out anew; the philologist speech-forms and citations, the chess-player games. Personages whose high positions in life require them to recognize many faces have wonderful accomplishments in that faculty. I have myself learned from my own experience that the same person by changing his employment may, if we may use such an expression, change the direction of his memory. I have also observed upon myself the influence of exercise upon the memory. Faraday was, it is well known, accustomed to lament the weakness of his memory. And when I (if I may compare small things with great) was engaged continuously for ten years, as he was during his whole life, with qualitative experiments, I remarked that my former good memory declined, undoubtedly because I needed each day, to continue my work, only the steps of the experiments of the day before. My memory began to improve again when I began to give lectures. Like the memory, the power of the most various mental activities increases with exercise and diminishes with neglect. We hear a great deal said in teachers' associations about how school-youth should not only appropriate what is taught them, but should also learn to exercise their sensations and perceptions, and make their mental powers facile. General and diplomatist, jurist and physician, mathematician and descriptive naturalist, chess-player and mechanician—all are practiced in their peculiar methods of thought. The effects of exercise extend into the emotional life: who would doubt that a Heine exercised himself in giving free course to the flow of his conceptions, in allowing them to strengthen themselves, as it were, in order to draw half deliberately out of the fountain the immortal complaint of self-created sorrow?

There are in psychology few darker points than the doubling of our I in this mental exercise. A final incomprehensible something in us oppose as subject another equally Incomprehensible as object, which is ourselves, yet also really is not, and forces it to a painful exertion, as at another time it compels its bodily substratum to practice itself in a composite movement, with aching muscles and other pains. Whoever comprehends the fundamental fact of metaphysics, that no arrangement and movement of matter can afford an explanation of consciousness even in its simplest form, will never think ultimately of conceiving these processes as mechanical ones.

This confessedly does not exclude our at least ideally, looking through to the play of the ultimate atoms of our present elements, somewhat as Herr Clausius, before our mental eyes, causes the molecules in a gasometer to perform their crossings and reboundings; and we may even confidently anticipate an important result, just the already declared fundamental distinction between exercise of the central nerve-system and exercise of the muscles, connective substances, etc. While in these tissues we deal with nutritive and formative stimu-

lation, by exercise of the central nerve-system is signified, in the first place, the making fluent certain molecular movements, partly through regulation and suitable re-enforcement of the impulses producing them, partly by the elimination of the obstacles originally opposing them. It must not, however, be said with this, that the highly vascular gray substance is not also nutritively stimulated by the activity incumbent upon it. Every thing indicates that, without a proper degree of activity, gray substance wears away as muscle does. But every increase in the fluency of definite forms of motion with a definitely enduring course is a newly acceding moment, indicative of exercise of the central nerve-system.

The more easy unfolding of a frequently repeated molecular movement in the ganglion-cells may be represented under the figure of a water-channel or a stone-slide, in which the path originally built roughly is so worked out and polished by the continuous passage of water, snow, and stones through it, that thenceforth water, snow, and stones reach the bottom surely and quickly, almost as soon as they begin to fall upon the ways converging toward it. All machines are improved with time through the wearing away of little roughnesses, so that their course becomes a more or less evenly or periodically varying one. Since they afterward become shackling through usage, they have, it seems, an age of development, one of bloom, and one of decay; and Tiede speaks of his chronometer as of a living being with a definite period of life. In order to bring nearer to comprehension the facilitating of the molecular movements in the ganglion-cells, it will be well to remember that the tone of a violin becomes softened by long use, as inversely India-rubber, that is not stretched at intervals, becomes brittle. The instructiveness of this comparison lies in its poverty. It shows us the utterly hopeless insufficiency of our knowledge in the face of such mysteries.

Herr Fechner has mentioned a particularly curious case of exercise of the central nerve-system, which sets anew in a clear light the comparatively slight importance of exercise of the muscles. In the Andoyer method of teaching to write, the pupil writes over with a pen for twenty times in succession the identical letters that have been previously written with a pencil, and the hand returns with a swing from the end of the line to its beginning, in order to write it over again without a pause. Ernst Heinrich Weber has observed in the case of his children that the left hand learned to write some at the same time with the right, but it wrote as in a looking-glass. We do not understand how the right side of the brain gained by exercise without the left hand moving during the exercise.

But equally whether we understand it or not, man is adapted to self-improvement by means of exercise. It makes his muscles stronger and more enduring; his skin becomes fortified against all injury; through exercise his limbs become more flexible, his glands more

productive. It fits his central nerve-system for the most complicated functions; it sharpens his senses, and by it his mind, reacting upon itself, is enabled to augment its own elasticity and versatility. Returning to our starting-point, we ask, Is not this one of the means, perhaps the principal one, by which the collectivity of living existence becomes a self-improving machine? As to the crystal, the parts of like structure and properties composing it; as to the whole organism, the elementary organisms whose life makes up its life, so are related to the whole of organic nature the single living existences, that is, the properties and functions of the whole are the sum of the functions and properties of the individuals; and if the individual living being is improved by exercise, does not this also sufficiently explain the progress of the aggregate? Lucid as the supposition appears, on a nearer trial it encounters serious difficulties.

First, only the most highly organized animals are amenable to exercise, or, what means the same thing, trainable. After the generally distributed companions of man, the horse and the dog, the most teachable animal is the elephant. Chamisso found intercourse with the apes on board the Rurik uncommonly instructive, "for," as Calderon says of the ass, "they are almost men," and he made the profound remark that they might be able to bring themselves up to the mark if they did not lack the property which Newton held to be one with genius, steadfastness. Carnivores, with the exception of the cheetah (*Felis jubata*), ruminants, and rodents, exhibit only moderate teachability; yet Herr Fritsch considered the draft-oxen at the Cape of Good Hope wiser than the horse, and in Brazil and Thibet sheep are trained to carry loads. Among the birds, the higher ones are the parrots, starlings, bullfinches, and canary-birds; the falcon ranks with the cheetah in teachableness. Chameleons, snakes, and carp are only moderately teachable. The training of fleas is only apparent; they always perform their tricks under a kind of compulsion. The immense host of other creatures all around us show no more aptitude for training than they do, for the reason that every animal within its own circle has no need of instruction; what we call instinct affords to animals, without effort of the individual, more than any exercise can. What practice could teach birds to build warmer nests, to find the way south more certainly, or bees to solve their geometrical, spiders their mechanical problems? Instinct and perfectibility complement each other as it were in the ascending series of animals to a growing sum, so that, the more instinct retreats before perfectibility, by so much does the living being stand at a higher stage. Secondly, although the animals we have named, and many others besides, are susceptible to exercise and trainable, animals still do not of themselves exercise and perfect themselves, but do so only when man takes them to school. Therefore, the animals around him appear less susceptible to training, the lower the stage at which he himself remains. Higher races of men would

certainly have tamed the beautiful zebra and quagga; the elephant, brought by Hannibal over the Alps, fell back with Northern Africa into wildness. Only nutritive and formative augmentation of advantages which an animal may have acquired in the wild state could come into consideration here, and these would have to be hereditary to lead to perfection in a course of generations.

This seems, thirdly, not to come to pass. No matter for how many generations man cuts off the tail and ears of dogs, tail and ears return with each new brood. The mutilation which the Semitic races have performed on their children for hundreds of ages, and which Islam has imposed upon a great part of the population of the Old World, is not yet chronicled in nature. If, now, artificial defects are not hereditary, how may we venture to suppose that those artificially acquired changes which appear as favorable results of exercise are conveyed through egg and seed to posterity?

To this argument the following considerations are opposed: Although deformities produced by exterior force are not inheritable, we nevertheless see that incontestably internally acquired changes are only too surely transmitted. Of this, the host of hereditary diseases affords an example. Since cellular pathology has shown that the most various heritable diseases of the tissues, the most malignant as well as the most harmless forms, move within the limits of the once given type, the difference appears exposed to light which separates an artificial deformity from a retrogression caused by disease; and it becomes comprehensible why in tame rabbits, the tips of the ears of which may have been idle for many generations, the ear-muscles disappear, and the ears hang down limp; and why the eye and visory substance of subterranean and cave-inhabiting animals waste away. But, even if a deterioration within the type of the species by lack of exercise becomes hereditary, formations dependent on nutritive and formative stimulation, which also remain necessarily within the type of the species, may likewise be transmitted. This appears even to be the case with the inworking of the central nerve-system in certain forms of emotion, of which the growing wild of the at first confiding bird on a formerly uninhabited island furnishes a classical example. Certainly animals in freedom do not, like those under human training, become habituated to definite, frequently repeated functions, yet hunger and love, hatred, cold, thirst, etc., drive them likewise to the frequent performance of certain acts. So, finally, might the innate superiority called instinct (*Kunsttrieb*) have been gradually developed through practice, and the more easily, as a certain degree of pleasure is connected with the execution of series of movements that have become familiar. If, then, instinct does all that is necessary for the maintenance of the species, there is no more room for further improvement or for development in new directions, and the species remains at the stage it has reached as bees and spiders have done ever since man has known them. We may confidently assert that at

the farthest no other actions of the ganglion-cells in the nervous system of these animals are possible than those which serve their particular, instinctive actions. As the artisans from Newcastle-on-Tyne, at the Bureau of Emigration of New York, replied to the question what kind of work they understood, "Packing files," so animals with a perfected instinct purchase their superiority with a one-sidedness which, because they can learn no more, makes them appear as if they had never learned.

Susceptibility to exercise first enters into the animal world when the maintenance of the individual and the species has been so assured, through outer and inner circumstances, that the creature does not need a further particularly one-sided development. We are, then, free to conceive, with an appearance of justification, that the strength of the muscles employed in flight and digging, the thickened epidermis on the palms of the hands and the soles of the feet, the callus on the prehensile tail and the buttocks of apes, the bone-prominences at the attachments of the muscles, and many other similar things, depend on the inherited consequences of nutritive and formative stimulation, while the most diversified kinds of skill may be traced back to inherited concatenations of actions of the ganglion-cells ; and this, whether we consider the waves which flow along apparently in a purely mechanical manner in the gymnotus-fin, or in the thousand feet of the wood-louse; or the intelligent posture of the French pointer, which, untaught, and without ever having seen one before, points at the lizard in the sub-tropical shrubbery as his ancestors pointed at the partridge on the plain of St. Denis. With Mr. Herbert Spencer meeting me in the same thought, which I believe, however, I have more sharply grasped, I deduced on a former occasion how, in such transmissibility of educationally derived aptitudes, possibly lies the reconciliation of the great antitheses of the theory of knowledge—of the empirical and the innate views.

Besides improvement by exercise, improvement by natural selection should not be left out of the account, if we would understand the adaptability of organic nature, for a threefold reason: First, there are numerous adaptations—I mean only the so-called sympathetic colorings—for which natural selection, not exercise, seems to afford an explanation. Secondly, plants, which are not less adaptable in their way than animals, do not enjoy exercise. A few phenomena of plant-life, reminding us of callus, and traceable back to nutritive and formative stimulation, belong rather to the region of healing and restoration, which is at this point closely connected with exercise. Thirdly, and finally, we require natural selection in order to explain the origin of the adaptability to exercise itself.

Indeed, the usefulness of exercise in its most diversified forms is in itself a deep problem. If we do not concede, as we can not scientifically, that the adaptive quality originated otherwise than mechan-

ically, we must conclude that in the struggle for existence those creatures prevailed which, by exercise of their natural functions, casually increased their fitness for those functions, or did this more than others, and that the beings so favored transmitted this their happy gift to their posterity for further increase. Thus originated an animal world susceptible of exercise; thus was originated natural selection itself, in the exercise of an important aid; finally, thus became the whole of life, like the individual, a self-improving machine. Herr Ewald Hering was also led to the conclusion that "even those properties of an organism may be transmitted to its posterity which it has not itself inherited, but has appropriated to itself under the particular circumstances in which it has lived, and that, in consequence of this, every organic being imparts to the germ that separates from it a small patrimony which it has acquired in the individual life of the mother organism and laid up for the grand inheritance of the whole race." The more perfectly this conception agrees with the one just unfolded, the more I am sorry that I can not follow Herr Hering when he represents the capacity of living beings to transmit acquired properties as an original power of organic matter, and explains it as a power of reproduction of the same kind with memory. To make the manifold processes on which the different kinds of exercise depend the expression of an original power, appears to me to be rather a darkening than an illuminating generalization. Herr Hering finds the *tertium comparationis* between the transmission of acquired bodily properties and memory in reproduction. But I see no similarity between the facile rolling-off of a definite molecular process in the ganglion-cells of the individual—which is memory—and the return in the offspring of a molecular arrangement imposed, in consequence of external conditions, upon the parent, which would be the transmission of acquired properties; and, if I did see a similarity, it would for me retire before the distinction that, as the name (*Gedächtniss*) indicates, memory is an attribute only of thinking beings. Herr Hering's unconscious recollection is a side-piece to the idea which men since Plato, to the injury of science, have suspected as a shaping force in the "great and little world," or to the life-force, in the face of which all the problems of physics and chemistry should lie open. Unconscious recollection is, moreover, not acceptable to me, because Herr Haeckel has eagerly appropriated it, and given it an important part in his plastidule theory.

I hold this play with groundless analogies to be the more hazardous, since, finally, it can not be strongly enough sounded that the transmission of acquired properties which we have thought of, with Darwin, Herbert Spencer, Hering, and many others, as possible and real under certain conditions, is proved, on further reflection, to be perfectly incomprehensible.

We are indeed indebted to the mechanical theory of gases for more just conceptions of the minuteness and the number of molecules;

viewed in its light, the number of possible arrangements in the ovum and spermatozoön grows into immensity. If we could imagine the head of a spermatozoön as large as the Great Eastern, and the space represented by it filled with a wheel-work as fine as that of the smallest lady's watch, our figure would still be far from giving any kind of a representation of the ultimate division of matter. It is thus clear that the head of a spermatozoön affords space and opportunity for the endlessly numerous arrangements and various motions on which the innumerable types and properties, with which this apparently so simple organism is charged, finally depend. It may then, at all events, be conceived that parental dyscrasies communicate themselves through the blood to the germs in the testicles and ovaries. But now let a group of ganglion-cells in the brain, if we may speak thus, be played upon to a certain molecule-dance-figure. The blood can not be changed by that. Consequently, the threads of the *plexus spermaticus internus* must so work upon the semen-cells in the seminal canal, the egg-cells in the after-growing Graafian pustules, that each act of exercise in the course of growth leaves its mark on the egg or on the spermatozoön, and that it is followed after years by the natural culmination of the same molecule-dance-figure in the corresponding group of ganglion-cells in the man or animal that has grown up out of that egg, or with the aid of that spermatozoön. How the *plexus spermaticus internus*, the connection of which with the brain is only of the loosest character, brings this to pass, can not be found out. The conditions are no more favorable for the comprehension of the kinds of exercise resting upon nutritive and formative stimulation.

As we have already pointed out, it appears that we might, in order to verify the transmission of acquired properties, invoke the example of hereditary diseases, from which our ancestors were in all probability free, which chiefly visit more highly developed manhood, and the transmission of which consequently resembles the transmission of acquired properties. Still, we may question whether the first epileptic attack, the first *migraine*, followed injuries which came upon a sound adult, or whether the foundation for them was not laid in the egg or the spermatozoön out of which the first sufferer grew. There remains, for the confirmation of this view—we will be honest—the transmission of acquired peculiarities, an hypothesis drawn solely from the facts illustrating it, yet quite obscure in itself, which receives only doubtful light through Darwin's "pangenesis."

I believe now, gentlemen, that I have justified the expression with which I introduced to you my intention to speak of exercise—that is, that it deserved a place in the scientific order of the day; yet I need not say explicitly how far I am from entertaining the thought that I have contributed anything essential to the fulfillment of that object. I consider that I have succeeded no further than more sharply to define the eventual phylogenetic office of exercise and the direction of the

evidences to be supplied than is usually done in the presentations of the Darwinian theory. In the immense field of research opened by Darwin after the fall of the zoölogical-paleontological dogma, the cultivation of which will employ the plowshares of many generations, we have plainly indicated to us one point where the work is urgent. On the other hand, a surer foundation might now be laid for the determination of one of the practical questions relating to exercise.

All are agreed as to the importance of bodily exercise for modern civilized mankind. With the knightly tournaments of the middle ages, in which, moreover, only an extremely small minority ever took part, physical training has more and more declined. Jean Jacques Rousseau, by his educational romance, gave the impulse to a movement that was fast taken up, especially in Germany, and, borne through the national and military struggles of the war of freedom, has culminated in the German turning.

Physical exercise had been pursued by us in this form for half a century when doubts were raised as to its fitness. To the German turning was opposed a theoretically devised form of physical training, the so-called Swedish movement, or gymnastics, the ground thought of which was the limitation of the exercises to extremely simple, although varied, motions. Since these movements were performed against resistance, a methodical strengthening of all the individual muscles was thought to result from them, and the true ideal of an athletic muscular system to be reached.

Again, from another point of view do we hear the superior fitness of the German turning doubted. The European nation which stands foremost in physical accomplishments, and which attaches the highest value to bodily vigor, the English, has till very recently known nothing like the German turning. Separated more than ever from the Continent during the French Revolution and the Empire, it was little affected by the movement of which Rousseau was the pioneer. Jahn's arguments, with their somewhat German-chauvinistic coloring, found but little acceptance there. The English, however, had less use for turning than the nations of the Continent. Thanks to the rural life of the wealthy classes and the common training of the youth in public institutions, a number of national games and contests (riding, rowing, games of ball of various kinds) had been formed, which afforded a superior empirical schooling in the various movements called forth in them; as the achievements of the English mountain-climber, who has just put Chimborazo under his feet, sufficiently illustrate. The passionate interest felt through the length and breadth of Sir Charles Dilke's "Greater Britain" in the annual contest between the dark-blue Oxford and the light-blue Cambridge oarsmen on the Thames can only be compared with the enthusiasm of the Greeks for their national games of competition, and goads the youth to the most earnest exertion.

Here we have the other extreme. The κατ' ἐξοχήν practical people rejects our physical exercises as too theoretical for its taste. The English at least did not understand at all, when, in answer to the question what sports we played at, an effort was made to explain our tool-gymnastics to them.

When we undertake to judge, in the light of our view into the nature of physical exercise, between these three forms, the German turning, the Swedish movement, and the English sport, the utter worthlessness of the second form for the bodily improvement of a healthy youth manifests itself at once. We have found that physical culture is not only exercise of the muscles, as it appears on a superficial view to be, but is quite as much, yes, more, exercise of the gray substance of the central nerve-system. The physiological value of the Swedish movement is expressed in the simple remark that it can strengthen the muscles, but has not power to make composite movements fluent. Now, in an extremely theoretical case, a physical training is thinkable, by which single muscles of a Caspar Hauser could be cultivated by gymnastics to a lion-like strength without the victim of such an experiment even learning to walk. The Swedish movement is only good for the purposes of physicians, to keep up or restore the efficiency of single groups of muscles.

Turning our attention to the relative worth of the German turning and the English sport, the latter evidently responds more than the former to the demands arising out of our physiological anatomy. Were the end masterhood in running, jumping, climbing; in dancing, fencing, riding; in swimming, rowing, or skating—then nothing could be more advisable than to practice equally and directly the necessary concatenations in the actions of the ganglion-cells, without pausing at the not practically applicable preliminary and intermediate steps of the German turning.

The German turning, however, offers not only the advantage of furnishing to any number of youth, of every age and condition, opportunity for exercise with the smallest amount of external preparations, and independent of often unattainable external conditions; it not only implies the moral earnestness of an effort that proposes self-improvement without immediate practical advantage as an ideal aim, wherein the superiority of the intellectual training sought in the German gymnasium may also be discerned; but, furthermore, the ingenious selection of German exercises, approved and refined through a long experience, results incontestably in a more equable perfecting of the body than can be attained where, as in England, the individual, following his own casually determined inclination, applies himself with ambitious enthusiasm to rowing or riding, to ball-playing or mountain-climbing. The youthful body, thoroughly trained after the German method, enjoys the extraordinary advantage that, like a well-instructed mathematician, it is provided with methods for every problem, with

ready forms of movement for every situation of the body. Put, for example, an English boy and a German boy on a road across which hurdles are thrown: the English boy will be sure to climb over somehow. According to the height of the impediment, the German boy jumps, or he climbs, props himself, and swings himself over.

Nothing prevents the German turner at pleasure carrying his more theoretical training into practical and immediately available forms of exercise, in which he, since he has learned to learn, speedily attains the skill which his natural ability permits to him; so we have been told that the gymnasiast soon does as well as the real-scholar in the laboratory.

After all this there can be no doubt that German turning, in its wise mingling of theory and practice, exhibits the happiest, yes, the most adequate solution of the great problem with which pedagogics has been busy since Rousseau—a truth which, after a short obscurity, is now hardly contested, but the physiological principle of which a few are beginning to understand.

I further remark that I do not class with German turning the so-called order-exercises, which, over-estimated as preparatives to exercising, and a lazy-bench for inefficient teachers of turning, belong, in my opinion, to the Kindergarten.

Hardly any progress in the knowledge of the laws of exercise has been made since Milo of Croton's famous experiment with the calf. Yet we are indebted to the creator of psychophysics for the beginning of the inquiry which is here possible. Herr Fechner daily for two months raised and dropped a pair of nine-and-a-half-pound dumb-bells conformably to the beat of a second-pendulum, from the hanging position of the hands to over his head, raised them and dropped them again, till fatigue compelled him to stop. The curves, the ordinates of which indicated the number of elevations daily, are instructive in a double respect. At first the exercise appeared to bear no fruit, then the results came out all at once; but they soon reached their limit. Volkmann had a similar experience in exercise of the senses. Herr Fechner's curves, in the second place, do not rise steadily, but in a serrated manner, according as weariness or increasing facility prevailed. These experiments might be made of useful application in the inspection of recruits for particular purposes.

Like individuals, so are whole peoples susceptible to exercise and of being trained; and here also an originally higher talent often does not go so far as continuous practice. The hardy, tough, North-German stock resemble the unpromising land, conquered only by obstinate labor, which we till. The Prussian is the self-made man among the peoples, yet he has not made himself without some help sent him by a favoring destiny. He has been eminently made, trained, and exercised through the care of a series of chiefs, unique in the world's history, culminating in the Emperor William. The present memorial day re-

calls one of the numerous acts of wise care whose blessed fruits we meet everywhere in this city, in this state. This institution, created when Prussia was still a feeble, small power, has grown with the state in importance and certainty of aim, and is now the nursery of physicians for by far the largest part of the Prussian-German army and for the Imperial German fleet. Whether scholar or teacher, each one of us feels how, with this elevated position of the school, his duty increases to perfect himself by means of incessant conscientious exercise.

NATIONAL NECESSITIES AND NATIONAL EDUCATION.*

By BENJAMIN WARD RICHARDSON, M. D., F. R. S.

I ASK myself if the system of education at present going on in our nation is a system which has a proper relation to the necessities of the nation. I look round me, to see the nation in chaos of thought and action ; in what Mr. Gladstone has correctly defined as social revolution in one part, and mental revolution in all parts ; mental revolution that might, by merest accident, by one or two days' shortness of food, from failure of foreign supply and panic thereupon, pass, after a few years of further chaos, into physical revolution. And the thought which occurs to my mind, as it must to all who think, is, Are we educating to prevent catastrophe? Are we educating the young to become useful, independent, and capable working members of society, ready to work with muscle as well as brain, in orderly and profitable form, or are we educating them to become mere troublers without design, repiners without hope, schemers without self-endurance, masters of the forces of Nature herself, knowing how to use them for temporary, selfish, insane objects, but not knowing how to apply them for splendid results and the general good?

The national necessities as the bases of national education are, first and foremost, these: that although in the early days of youth the three simple elementary educational practices of learning to read, to write, and to calculate, are necessities for the time, they are comparatively valueless unless combined with further necessities of a physical kind—namely, sound and systematic muscular training ; freedom of breathing, and circulation of the blood ; practical training, so that the body can be structurally built up and sustained in health ; preparation for all duties requiring precision, decision, presence of mind, and endurance ; and readiness to acquire any craft or handicraft that may bring a useful living ; in a word, an education that shall bring the

* From a Lecture delivered before the Society of Arts, April 28, 1882.

mental and physical qualities of every person into faithful harmony and good-will.

I, like some of my colleagues at the School Board, would break up the monotony of the schoolmaster and the schoolmistress, and would give those excellent workers as much variety of teaching as any of them could desire. But that variety should be physical, not mental; play, rather than work; training of the muscles, and, I may say, of the skeleton too; of the lungs, of the heart, of the digestive organs; of brain and nerve for action—not of brain alone, and again brain, and brain, hour by hour, all the day long. I, like others of my colleagues, would encourage economy, not by keeping things as they are, but by saving some part of the two fifths of the money now expended on teaching to spell, and by laying it out in teaching how to walk with grace and ease; to sing with correctness; to swim; to learn the use of the arms, and fingers, and hands; and to become men and women in the strict sense of the word, without danger of retrograding a hair's breadth in the Darwinian line.

I said, in my address at the Health Congress, at Brighton, what was quite true, that I had never in my life seen a healthy child, by which I meant that I had never seen a child that had not in it either some actual or latent constitutional disease. Touching the subject now in hand, it is equally true to say that it is all but impossible to find, in the board schools of our large towns, any semblance, critically viewed, of health. Constitutional taints, which under favorable circumstances may often be concealed, and which may or may not be apparent, are there. Various conditions of disease are there, independently of the tendency from heredity; there of themselves, in some irregularity of body or limb, in some imperfection of sense, in some deficiency of quality of blood, in some feebleness of respiration, in some nervous irregularity of function, in some shade of mental aberration.

The field of disease which is presented in some of the schools situated in crowded localities is indeed a sight at once for anxiety and pity. To the eye of a physician who, like myself, has spent many years in dispensary practice, it tells a story which is absolutely painful, if he permit the results to be calculated out in his mind at leisure hours; if, that is to say, he compares what he has witnessed in his survey with what he has learned, from long observation, of the meaning of the phenomena in the history of life. It is not necessary to strip the children, percuss and sound the chest, examine the spine, or practice any of those refined arts of diagnosis with which he is familiar. He reads from the indications of temperament, of expression of countenance, of color of skin, of position of limb, of build of body, of gait, of voice, sufficient outward manifestation to discern what is the true physical state, what are the stamp and extent of disease, what is the vital value of the lives generally that are before him.

Foremost among the evils which are thus presented to him are those conditions of disease known as anæmia and cachexia. Strictly, these are not diseases like diabetes, bronchitis, or defined affections having a regular course, but they are states of diseased form, which by their presence indicate a faulty nutrition at the period of life when good nutrition is most required, and which can not long go on without insuring the construction of an impaired bodily organization. The blood is not being duly oxygenated, and food, therefore, though it even be fair in quality or quantity, is not properly applied. The nervous system is imperfectly built up; the skeleton is imperfectly built up; the muscular system is imperfectly built up and sustained. How can the improvement which is called scholarship be turned to fitting account in such recipients of it? I watched recently the afternoon working of a large class of scholars, and counted one third of them under the most decisive influence of these conditions of disease. Of the affected, there would not be, in the ordinary averaging of life, twenty years of existence under the course that was being followed. The one saving clause in their case was development by physical training, and that was withheld. The one destroying clause in their case was over mental work, without the physical training, and that was assiduously and regularly supplied.

With or without the anæmia and cachexia, there is the constitutional disease, struma or scrofula, present in these classes. The instances of this kind, in varying degrees of intensity, are most numerous. This condition, again, is a mal or bad nutrition. It, as much as cachexia and anæmia, with which it is so often allied, is fostered by the prevailing system of mental pressure.

With these two conditions before the eye, there is to be seen here and there in the classes, of both sexes, but of the girls especially, the specimen of the phthisical or consumptive subject. In a class of fifty I pick out three thus doomed, if their circumstances be not changed, six per cent, certainly a moderate proportion. The disease has not positively developed, but the probability of its developing is all but certain, unless it be checked by the one or only remedial or preventive method—freedom from nervous exhaustion, combined with physical exercise in open breathing-space. Such preventives are not supplied, but undue nervous exhaustion and confinement are both supplied, and so the fatal disease is systematically fanned from latency into activity.

Spinal deformity and irregular construction of the skeleton is another condition of disease, or actual disease, readily detectable in these classes.

Miss Löfing, speaking of her experiences as to the girls which have come under her notice, reports that they are, as a rule, very flat-chested, that there is evidently much spinal distortion, and that lateral curvature of the spine is common among them. This, which is equally true in respect to boys, is accounted for by Miss Löfing in terms which

show that the present school system does more than simply permit the mischief that is progressing, it actually fosters it and promotes it. Asked "to what the effects are chiefly ascribable," she replies: "A part is ascribable to home neglects; but the greater part of it is due to excessive and prolonged constraints under the common-school conditions: too long sitting on badly constructed seats; but, with good seats, they are kept in bad positions in long writing exercises. The common bad position is, indeed, prescribed by the Government School Inspectors. I have found that, to obtain the school grants, the children are so constrained as to exclude the exercises that are needed for their bodily development."

The present system is not only a violation of physiological but of psychological law. The powers of receptivity of the minds of children of different ages have been tested experimentally, with as much care as physicists take when they are treating in their experiments on the relationships of ordinary matter to force. Certain brains can take in so much, and no more, according to age. The capacity grows with cultivation and skillful teaching, no doubt, but it must be permitted to grow. In the very young a lesson of a minute may be all-sufficient. Later, of three minutes, five, ten, fifteen, and so on, to one hour, two, or three. But to this there is a limit, and it is probable that, with the best scholar of primary-school age, the powers of receptivity rarely extend beyond a period of two hours and a half of direct teaching. Teachers of various districts, and of different countries, have testified in respect to this point, and while they have explained, from direct observation, that the receptivity varies in different children according to difference of temperament, physical health and build, as might very well be expected, the receptivity at one time, in all children, ceases at the end of three hours.

Proposed Reforms.—From these considerations let me now turn to the reforms which we, who are urgent as to reform in the present educational system, have in view. We reason that the existing system is not a basis for the national necessities. We are of opinion that in the future the education of a mental kind now being supplied will be imperfect and doubtful, nay, it may be of dangerous use, unless it be so laid out with physical culture that a perfect or comparatively perfect health of body shall go with it and sustain it. We urge that, as we must either educate health or disease, it is best to educate health.

The design we have in view, then, includes several heads, which I may arrange in the following order:

Physical Culture of the Body.—We urge that education should be so distinctly physical, that the body should be in no respect less improved than the mind at the close of the educational career. We follow, in this regard, the teaching of the Platonic philosophy, in which the master insists that the symmetry of mind and body be cul-

tivated and maintained, without which there can not be beauty, there can not be health. We urge that this is the only sure way of keeping up a strong and vigorous and independent population, that shall understand how to utilize the home resources of land and industry, and keep the land and industry in the possession of our and their descendants.

The system of education that is now being carried out seems to us to promote in no way whatever this necessary intention. In the "standards" we find no efficient instruction of a technical kind that even in the barest hypothetical style teaches the principles of useful arts and appliances. Practical details of industries and of modes of learning industrial occupations are thought to be of less importance to the scholar than a knowledge of geography, construction of language, physiology, and history. It is no wish of ours to ignore studies of the kind above named, but we consider that elementary instruction in details of inventive and industrial pursuits holds a first place, and that in a country like ours in which so much, in which, in truth, almost everything, depends on individual perfection in some useful art, such elementary instruction ought to have the place it deserves at once and for good. We think, moreover, that the instruction should not be purely theoretical. We contend that it should include elementary training in useful work of a practical kind. We do not see why work-rooms should not be set up in schools, in which boys should be taught the use of the lathe; the beautiful art of wood-carving; the skill of the draughtsman; the method of distinguishing metals, and other simple experiments in chemistry; the arts of swimming and riding; the art of distinguishing colors and signs at a distance; the practice of mensuration, and a number of other good and useful branches of physical learning, which, whether the boy remain at home or whether he emigrate to another country, will always be to him a direct assistance, a means of earning his bread, and an insight and test of his particular ability or aptitude for the vocation by which his subsistence will be most easily obtained.

Extending this principle of practical teaching to the female sex, we would have the girls well trained, both theoretically and practically, in those occupations which in the course of life fall more distinctly under their exercise, management, or supervision. We know that in the schools at present girls are taught sewing and a few other useful industrial accomplishments. We would extend these instructions. We would have the girls instructed in modeling; in the art of coloring and painting on glass and porcelain; in the various processes of selecting, sorting, preserving, and preparing foods for the table; in the cleaning and ornamentation of drawing-room ornaments, and in all the works pertaining to domestic life. The girls in our schools would, as we believe, make more rapid progress in mere book-learning if one half of the time now devoted to books were devoted to that

other branch of practical education which forms the greater part, in practice, of the future of the womanly life. We consider that evidence in proof of this belief has already been offered, and we suggest that a girl trained in the manner now described would, in this country, or in any other country into which she might emigrate, be far better fitted for the duties pertaining to any station she might hold, than if she were simply dismissed from school primed with the standards, and standardless.

Life-learning Tendencies.—We contend, secondly, that the education of the young of all classes, and of the poorest classes chiefly, should be so framed as to lead to the inducement of making the acquisition of knowledge a taste instead of a task, a pursuit instead of a labor. We contend that if the present system is pursued—in which children who are not by heredity born to mental occupation, and who are not physically privileged to acquire information, are, by sheer force, driven through the hard and fast lines, fenced out by the books called standards, at a pace that shall make them complete their education irrespectively of temperament, health, ability, before their thirteenth or fourteenth year—the pressure, amounting in every case to a hardship, will merely have the effect of causing them to cease to learn when the pressure is taken off. We insist upon this, that the system shall be so modified that there shall be no mental pressure at all, but a mixture of mental and physical teaching which shall bring the mind into desire for knowledge after it is freed from the necessities to acquire it.

Aptitude for Productive Ability.—A third advancement upon which we lay great stress is, that the educational system shall be of a kind that shall render the body of fitting aptitude for productive ability. We argue that, unless discrimination is used by the teacher for detecting the natural or hereditary capabilities of the scholar, there must be failure in result of the most serious kind; failure that will tell upon all the productive industries of the country, so that agriculture, the various industrial arts, the various labors which call for muscular skill, activity, and endurance, will be sacrificed, or largely reduced in effective value. In insisting on this practice of developing productive ability, we are sustained by the belief that nothing could be lost by the effort in the way of actual education. We are of opinion that the time saved by the adoption of varying conditions of school-work would prevent the injuries now incident to the fixed rules under which the educational system is enforced, and in this view we are supported by the opinions of the most practical teachers.

We maintain that courses of physical training such as we wish to introduce would have a distinct formative effect in mental habits. This is especially seen in the industrial and reformatory institutions where the same principles of mixed physical and mental training have been adopted as prevail in the district half-time schools. A draft

report prepared for the consideration of the Education Committee says of them:

"In the long-time schools, during the time the boy is kept waiting under restraint, his mind is absent from his lessons, which are commonly so uninteresting as to be repugnant to his voluntary attention, and his thoughts are away on cricket, or some sort of pleasurable play, so that he generally only returns, upon call to the lesson, as to a task to be got rid of. Under the restraint of separate confinement in a prison, the mind of the young criminal can not, as is shown by his action on release, have been occupied with compunctious visitings of remorse, as commonly assumed. His thoughts are of his ill-luck under the wide chances of escape of which he has had experience during all the time he has been at large before detection, and of how he may have better luck when he gets out. He is exhorted to be good: but the child of the mendicant or of the delinquent does not see his way to doing other than he has done before; and why should he, so long as he feels his inaptitude of hand and arm for industrial work? Be this as it may, under the common conditions of restraint in the district schools, or in the reformatory schools—all of which, comprising some thirty thousand children, are now of necessity conducted on the half-time principle of varied physical and mental teaching—the pupil is placed under entirely new and opposite conditions, by which bad thoughts are excluded and good thoughts induced and impressed from day to day by practical work from the like of which he may hereafter get something good for himself. In the morning he is roused out of his sleep to attend to his head-to-foot washing and his dressing. Then he has to go with others to his breakfast; after that to the school, where, with his class, he is kept to the simultaneous class lesson without waiting, to which he willingly gives himself, as it is not over-wearisome, like the lessons of the long-time schools. He may next have to fall under the drill-master or the gymnast, and, if he stumble or fail, he is jeered by the other pupils, or reproved by the corporal; but he soon participates in the zeal and competition of common lively action. He may on the following day have a swimming-lesson. He may next have some naval exercise at the mast, where, unless he holds on, he will fall into the net spread beneath to receive him. Then he has to go to the workshop, where the work-master—in carpentry, in shoemaking, or in tailoring—keeps the mind, the hand, and the eye, of the pupil intently occupied. His day's occupation may be varied by freehand drawing, so useful to handicrafts, or by lessons in singing, or, if he be a very good and apt boy, by lessons in instrumental music. The enumeration of the incessant occupations may sound as of severe labor; but the course is varied by "relief-lessons," and it becomes so little irksome that an interruption is disagreeable, and an exclusion from any part of it is acutely felt as a punishment. When some parents exercise their right of taking away children from the district school,

the children are not glad, but commonly cry at having to leave the institution, to part with their playmates or their workmates, and to go home. As the physical and industrial exercises have been improved, desertions have diminished and the outcomes bettered. From morn until night bad thoughts are much excluded, and comparatively good thoughts—thoughts of doing better for themselves by work and wages, and by all honest and esteemed position—are generated and impressed. The teacher can not look into the mind and see what effects, or whether any, have been produced by his precepts. But the drill-master or the work-master does see the valuable primary moral principles of attention, patience, self-restraint, prompt and exact obedience, in outward and visible action. The general result is that the pupil gets interested in what he does, and does it with a will."

We are strongly of the opinion that by the introduction of physical training the end will be accomplished of reducing natural crime.

Lastly, we submit that, to insure the future happiness and serenity of the people of the future, the children of the present should have their mental and art training varied by making the subject of recreation a scientific branch of study among all who are engaged in educational work. In such advance, we should have the means for recreation made the means for imperceptible instruction in bodily and mental powers, so that, having never unduly severed them from the tastes of the scholar, they shall be true resting-places, useful as well as pleasing diversions from mental and physical labor.

I have now put forward our programme. It is framed on what we conceive to be the basis of national necessities. A few concluding paragraphs may be taken as proposed resolutions to explain the mode in which we would carry out the reforms we have in view:

1. We propose to lessen the tasks of a mental kind in all schools, by the introduction of what is practically a half-time system. Believing that the brain of the child under fourteen years of age is sufficiently charged, to be safely charged, when it has been subjected to three hours work in book-teaching, we assume that this period per day of such teaching is sufficient for all useful and safe advancement, that the children would have more than they could learn, and would retain more than they need retain on this plan. We propose at the same time to make inspection into such book-learning less critical and less severe, with an institution of inspection into physical capability as a part of the inspection, in place of the part given up to book standards.

In connection with this department we propose that there should be at stated times a physical inquiry, by competent authority, into the health of every school and every scholar, and that as much special encouragement and reward should be given to scholars who present the best *physique* as to those who present proofs of superior attainments in the standards.

We propose further that this great change shall be effected by

utilizing the time thus taken from books in application to lessons of play, exercise, or work that shall be useful in developing the body, and in making it apt to attain proficiency in physical arts and sciences. We would suggest that, in the school itself, the means for this physical instruction should be provided ; but we would not by any hard and fast line hold by the school as the only place. If it were found in any case that a scholar had the means, in his half-time, of following any proper and profitable occupation without injury to himself, we should let him follow it, by which plan, as we believe, the sting of the compulsory clause in the education act would be most effectually blunted.

2. We propose that, while the mind of the child shall not be surcharged with book-learning at a time when the body is in the most critical stage of development either into a sound and helpful or into an unsound and helpless body, there shall be made a provision in the school itself, by which education shall be allowed to go on after the usual prescribed time, in which it is presumed that the education is completed.

3. We propose, in the introduction of physical education into schools, that it should be at once of the simplest and best kind ; not a system of one particular character, but one which should combine everything that is useful in various systems, and which should interest the scholar, while it develops his physical life. We agree with an observation made by Mr. Charles Roberts, in a letter in which he says :

> I have examined with some care, from a physiological point of view, the various systems of physical education, but I am not satisfied with any of them. The military drill, in use in many schools, puts too great a strain on the lower limbs, and too little on the arms and trunk, and, though the exercises are useful for discipline, they are monotonous and wearisome to children, and may be injurious, by inducing flat-foot and other deformities of the body. On the other hand, the exercises in ordinary German gymnasiums are generally too severe for children, and not sufficiently under the control of the non-medical teacher; their expense, moreover, places them beyond the reach of elementary schools. The Swedish system, again, as taught in the board schools, lacks spirit and energy, from the entire absence of apparatus, and therefore of motive, to attempt or complete a definite object—a defect which Miss Chreiman's system has removed to considerable extent, by the limited use of simple apparatus.

4. We propose that there should be introduced into the system what may be shortly explained as systematic training of the senses, so that the senses of sight, hearing, touch, and even smell, should be brought up to the best standards of perfection. Such training, we are of opinion, could be carried out by means of lessons and of simple apparatus, and would, in the course of carrying it out, afford facility for practically testing the capacity of every scholar, and his fitness or unfitness for the after-duties he may be called upon to undertake. In

America, they have had appointed tests for the proof of color-sight, so that it may be determined, when a man applies for duties in which color-sights are required, whether he can distinguish color. If our design were in operation, no scholar would leave a school without being made fully acquainted with his particular failure or capacity for this and such like occupations.

5. We propose, finally, to use the time that we wish to extract from book-learning, in some, and indeed in a free degree, in the cultivation of certain of the more refined and pleasure-building arts. First among these we would place music, as the primitive of recreative pleasures. We observe that our children are well and happy when they can sing; we see men and women gathered together, and find the height of mirth and happiness when somebody gives a song or a tune. In the most refined society, music is the joy of life; in the lowest dens, men, hardly above animals, when they meet to be amused, sing. It may be that in all these positions the music is very bad, but it is there, and it extends through creation. Here, therefore, is the first recreation to be scientifically studied. Make a nation, we say, a musical nation, and think how you have harmonized it, socially, morally, healthfully. We can not begin to teach this recreation too early or too soundly.

We ought to begin by making the learning of notes in succession—the scale of musical chords—coincident with the learning of the alphabet. Next, the intervals should be taught, in a simple but careful way, so that melody may be acquired, and the art of sight-singing attained. From this elementary basis should follow the simplest forms of time, after which a plain melody could be read with as much ease as the reading of the first story-book. Simple part-songs, leading to endless delight, would succeed in exercise; and a true and natural language in sweet sounds would be the property, in one generation, of all the nation. In addition to music, we would, as a matter of course, introduce other pleasant recreations, such as dancing, gymnastics, and all those muscular games and exercises which, by discharging naturally the nervous force, relieve the mind of mischievous intents and provocatives to destructive habits.

This is the programme we would put before the nation, in respect to the grand revolution we consider necessary, of placing national education on the basis of national necessities. Should it be urged that what we propose is too essentially physical or muscular, we answer that all education is, in the strict sense, physical and even muscular. Speech is muscular, expression is muscular, writing is muscular, composition is muscular, as much as mental. It is as purely a muscular act to decline a Greek verb as to walk across a tight-rope; only that the muscular movement, hardly so refined, is more obscure. We meet two men, one of whom is seen to move with ease and grace, the other with dullness and weight. We say, how accomplished the one, how un-

couth the other! We hear two men discourse—the one with elegance, precision, style, the other with hesitation, blundering, rudeness. We say, how accomplished the one, how uncouth the other! In all these cases, muscular force has played its equal part with mental aptitude, or inaptitude. We see a man who has not been educated to grace of manner, or speech, or thought, assuming the part of a man of grace, manner, and thought, and, by much study, sustaining the character for a short time, as on the stage. But we know that man only acts; he is not trained to the muscular skill that can carry him through all parts of life with equal grace, though he may, by intense labor, attain a minor part, and be perfect in it.

We know that no one who late in life enters a vocation requiring certain qualities, like that of a physician, a surgeon, a preacher or pleader, a commander, a pilot, an engineer, a player, can gain that full self-possession which comes, as it is said, naturally, to the man who has been from early life trained in the work. Here again the failure we affirm is muscular as much as mental. The concealed muscular mechanism is not in working order. The mind may issue its commands, but, if the muscles fail to obey, the mind, like a general whose red-coats are undrilled and impervious, may break itself to imbecility and produce no results beyond hopeless and helpless confusion and dismay.

So we contend for the physical education of all our young, on the lines I have laid down, as the stirring want in this stirring time. Our intention is to make this nation a nation of heroes as well as scholars; a nation that the sculptor can describe as well as the historian; a nation that can hold its own in the scale of vitality, and protect its own by the virtues of courage, physical prowess, and endurance, as ably as by statesmanship and knowledge, more ably than by expediency and craft.

ACOUSTIC ARCHITECTURE.

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In the construction of a building in which large numbers of people are to be gathered together to listen to music or speaking, it is highly important to consider the conditions which shall best allow the sound to be carried from the musician or speaker to all of the hearers. It is the aim of the present article to place before the reader an outline of the art of so constructing buildings, and to present certain general principles upon which acoustic success depends.

The subject divides itself naturally into three parts. In the first is considered the effect of the condition of the air within an auditorium

upon its acoustic qualities, and it will be shown, as would naturally be expected, that the condition of the medium which conveys the sound exercises a very considerable influence on the facility and accuracy with which the sound is conveyed. In the second part is considered the effect of the arrangement of the walls which inclose the auditorium, and of the materials of which these walls are composed. In the third and last part there are discussed several minor points, attention to which will aid in the securing of a building which shall be good and not bad for sound. These three headings, it is believed, will cover the whole ground.

It seems almost self-evident that the condition of the air, which is the medium by which sound is conveyed from one part of an auditorium to another, will exercise a considerable effect upon its acoustic properties. An experimental inquiry shows us that such is the case. What peculiar condition of the air is it that affects the transmission of sound? Whether the air is hot or cold, wet or dry, whether it contains a larger or smaller percentage of oxygen, nitrogen, or carbonic acid, seems to have no effect on its acoustic properties. But whether the air is quiet and mechanically homogeneous, or whether there are mingled draughts of hot and cold air moving in various directions, does seem to have a considerable effect. In other words, the motion of the air within an auditorium does have a very perceptible effect on its acoustic qualities.

Probably most readers have noticed, or in any event they have seen recorded, instances in which sounds of very ordinary intensity have been heard, and heard distinctly, at a very considerable distance from the source. In particular, the author remembers an instance which came to his notice one summer afternoon, while resting half-way up the side of one of the hills near the Green Mountains. The hill sloped gently to a meadow at the foot, and its sides curved somewhat like the walls of an amphitheatre, of which the meadow was the floor. Nearly a mile away, across the meadow, a man was mowing grass with a mowing-machine drawn by horses. The day was slightly cloudy, and from the mower, up the side of the hill to the observer, was moving a slight, hardly perceptible breeze. The air was optically very clear, and appeared to be rather dry. The click of the mowing-machine was heard with wonderful distinctness, but the author was not a little surprised when, the machine having stopped for the moment, the "Go along!" of the driver was plainly heard as he urged his horses on. Not only were the words plainly intelligible, but the provincial twang peculiar to the country-folk of that region was distinctly distinguishable. Here the human voice, raised probably very little above the ordinary tone, and not at all above that of a preacher in his pulpit or an actor on the stage, was distinctly heard, and with all its peculiarities of quality, nearly a mile away.

Another instance is that mentioned by Sir John Ross in his account

of his voyage to the polar regions. He says, "I found no difficulty, in that cold and quiet air, in conversing with a man a mile away." It will be noticed that in both of these cases the air was mechanically homogeneous; that is, there were no alternating currents of hot and cold air.

In striking contrast with these may be mentioned the condition of the air as a vehicle for sound in the burned district of Boston, just after the fire had swept over it. There were many places, where there was a mixture of hot air, smoke, steam, and currents of cold air, in which the shouts of two people hardly a hundred feet apart, although audible, were so confused and indistinct as to make communication entirely impossible, and this too in quiet parts quite remote from the scene of conflagration. This effect was noticed when there were mingled currents of hot and cold air. That is, the air was mechanically heterogeneous. Humboldt speaks of the great difference in transmissive power for sound of the tropical air during the day and at night, and attributes this difference to the homogeneous condition of the air at night as compared to its heterogeneous condition in the day-time, due to convection-currents rising from the heated sands.

A large number of instances might be cited, and we should find that a clear homogeneous air transmits sounds readily, while an atmosphere broken by alternating convection-currents of warm and cold air is a very poor vehicle for sound. The explanation of this is not difficult. The original ray of sound, striking upon the first current of air, is partially reflected and partially transmitted.

The loss of the reflected portion causes a decrease in the intensity of sound. The transmitted portion, striking upon a second current, is likewise divided, and its transmitted portion continues to be so divided as many times as there are variations in the density of the air. Its reflected portion, as well as that of all the succeeding reflections, instead of being wholly lost, is interrupted in its backward course by the first current of air, and reflected along the path of the primary wave, but following it at an interval of time, depending upon the thickness of the current of air. Each reflection being thus again and again divided and reflected, we have, following close upon the primary wave, a multitude of secondary waves, which, falling later and later upon the ear, greatly mask the distinctness of the original sound, and give rise to indistinctness and confusion.

It is evident, then, that in order to procure the proper propagation of sound, one must do away with these air-currents. It must be remembered, however, that, when large numbers of people are crowded into halls, the air within is usually subjected to very considerable disturbances in order to obtain even indifferent ventilation. Registers, sprinkled here and there over the floor, send up their currents of hot and cold air. Opened windows or other cold-air ventilators send in their currents of cold air. If these currents could be made visible to the eye, as they can be detected by proper apparatus, we should see

that hot and cold currents do not readily mix, but fill the whole auditorium with alternations, continually varying in temperature and therefore in density and relative motion.

The proper solution of the problem is to admit the air in large volume, and at the proper temperature, at one side of the auditorium, carry it bodily across the room in one large mass as nearly as may be without break of homogeneity, and exhaust it at the other side. Or it may be introduced through a perforated floor and rise to be exhausted at the roof. This plan has been tried with success; the air, being first brought to the proper temperature in the basement, passes up through myriads of gimlet-holes, and is exhausted at the ceiling by means of numerous openings connected with a high chimney or other means of producing an exhaust.

An example of the first method is shown in the Baltimore Academy of Music, where the author was able to make some experiments to determine how far acoustic properties were actually dependent upon the condition of the air. The ventilation of the house is arranged as follows: The whole supply of fresh air is admitted at the back of the stage, is then warmed, then crosses the stage horizontally, passes through the proscenium, and then, somewhat diagonally toward the roof, across the auditorium, in one grand volume and with gentle motion, so as to almost entirely prevent the formation of minor air-currents. It is exhausted partially by an outlet in the roof, and partly by numerous registers in the ceilings of the galleries. From this central outlet and from the large flues of the registers, the air passes into the ventilating tower over the great chandelier, which supplies, in its heat, a part of the motive power of the circulation. It is further expelled from the tower by means of properly constructed ventilators. The acoustic properties of this house are universally agreed to be very superior.

The experiment made by the author consisted in stationing observers in various parts of the house while the performance was going on, with directions to note, at intervals during the evening, the readiness with which they could hear what was said on the stage. The observers were ignorant of the experiment to be tried. Observers A and B were stationed in the first, and C and D in the second balcony, from 8 to 10 one evening, when Neilson was playing "Rosalind." At 8.50 the ventilators were closed, so as to interrupt the normal circulation of air; and the doors into the lobbies, and thence into the street, were thrown open, that counter-currents might be established. At 9.20 the doors were closed, and the ventilators set right. The testimony of the observers was:

A (first balcony).—8 to nearly 9, good; for about half an hour, bad; afterward much better.

B (first balcony).—8 to 9, good; 9 to 9.30, bad; 9.30 to 10, good. Strong current of air felt from door a little before 9.

C (second balcony).—8 to 8.50, good; 8.50 to 9.20, bad; 9.20 to 10, good.

D (second balcony).—8 to about 9, good; 9 to 9.20, bad; 9.20 to 10, good.

An examination of the foregoing data can leave very little doubt that the condition of the air within an auditorium exercises a very considerable influence upon the facility and accuracy with which sound is conveyed.

The Academy of Music, in Baltimore, is an example of how a desirable condition of the air may be obtained. It must not be supposed, however, that acoustic success depends entirely upon the condition of the air. In fact, the condition of the air is a matter quite secondary to that which next comes up for discussion—the material and arrangement of the walls.

It is not uncommon to find churches or halls built nearly square, with a speaker's desk at one end, and a bare wall of stone covered with plaster opposite. If one goes into such a room when it is empty and speaks from the desk, he notices a loud and disagreeable reverberation following each syllable, which, if the room be large enough, comes back to him as a distinct echo. When the room is filled with people, this resonance or echo will considerably decrease; but, in such a room as we have described, it will not by any means disappear.

If now we choose a similar room, but with walls sheathed up with thin boarding or a thin layer of plaster laid on to light laths and having a free air-space behind, we shall, in all probability, find that, when this room is filled with people, the echo or reverberation will have almost if not quite disappeared. This is a comparison that the author has often made, and it gives the cue to the whole art of choosing the materials of which the walls are to be built. They must be built of such material and arranged in such way that they shall *absorb* and not *reflect* sound-waves falling upon them.

When the speaker utters his first syllable, the sound goes out in straight lines from his mouth to all parts of the house. So much of it as goes directly to the ears of the audience is effective, but all the other rays of sound ought to be as completely as possible absorbed and destroyed, else they will be reflected from the walls and ceiling back to the audience; and, arriving at their ears somewhat later than the direct sound, will give rise to the confusion or echo whose apparent effect is to bridge each syllable of the speaker over into the next, and so cause apparent indistinctness of articulation.

The presence of an audience in a room causes the absorption of such words as would otherwise be reflected from the floor, and thence to the walls, and so back and forth. But it is out of the question to cover the walls and ceiling with an audience. The absorption of the sound is, however, sometimes effected by draping heavily with cloths; but it has been found by experiment that there are other materials,

more conveniently handled, which answer the purpose much better. A sheathing of thin pine-wood, lightly suspended, particularly if there be a large and free air-space behind it, will absorb sound very completely.

There is a very great difference in the absorptive power of different wall materials for sound. Walls of stone and brick absorb hardly any of the sound that falls upon them, but reflect it nearly all; while walls of thin and dry pine-wood absorb a very much larger proportion and reflect comparatively very little. In order to determine the absorptive power of different wall materials for sound, the author has made bold to extend the general principle in radiant energy, that "bodies which give out rays most readily when excited absorb them most readily when exposed to their action," to such rays as we have in sound. Suspecting from analogy that this principle might be true for sound-waves, he has proved by experiment that this is, at least in a general way, the case, and has then devised the following method of measurement:

If a tuning-fork be set in vibration and held against a wall, it will communicate its vibrations to the wall and the wall will give out a sound, which sound will be feeble or intense just in the same proportion that its capacity to absorb sounds falling upon it is feeble or intense. In this way the absorptive power of different wall materials has been measured, and a few of the results are arranged in the order of this power in the following table:

1. Thin and dry pine sheathing, lightly supported or in panels.
2. Corrugated iron.
3. Heavy wood paneling.
4. Thin, dry, and hard plaster on light laths lightly suspended.
5. Heavy plastering on laths lightly supported or attached to wooden walls.
6. Heavy plaster on laths closely fitted to brick or stone walls.
7. Thin brick walls.
8. Thin brick walls covered with plaster directly laid on.
9. Thick brick walls.
10. Marble and other stone walls.

A comparison of this table with results actually obtained in churches in which these different wall materials are used has amply proved their correctness.

There is one fact of considerable practical value that seems especially worthy of attention. Corrugated iron, we see, has a very good absorptive power for sound, while it is durable, safe from fire, and can be easily worked into any ornamental forms desired. It seems, therefore, peculiarly fitted for the lining up of an auditorium. Bethany Church, on Franklin Square, Baltimore, is built entirely of this material, and is a decided acoustic success. We need, however, not only to attend to the material of the walls, but to their arrangement as well.

While a plain blank wall opposite the speaker will throw back a strong reverberation, if this wall be broken up by recesses, or spaced with pilasters, or if a gallery be extended across it, the reverberation will be much less.

The lining of the walls should, if possible, be placed at a considerable distance from the main wall, and supported by it so as to allow as free vibration as possible. Thus when other considerations require that the walls of a building shall be of stone or brick, the acoustic qualities may be recovered by lining up with thin pine, corrugated iron, or a thin coating of plaster on light laths, and suspending this lining as lightly as possible and at a considerable distance from the solid wall. The arrangement of walls in panels is a very advantageous one, as each panel may be so constructed as to be easily set in vibration. Perhaps the ideal arrangement would be an auditorium with brick walls, within which is a shell made up of thin wooden panels, and placed at such a distance from the solid walls that the passage-ways to the entrances on the floor and various galleries may be placed between.

In this connection it becomes necessary to discuss the proper shape to be given to an auditorium. A good way to arrive at this is to consider first an audience in the open air on a calm day. The open air on a quiet day, when the atmosphere is not disturbed by convection-currents, is probably the best possible place for speaking to a large number of people. Wesley is said to have preached successfully to twenty thousand people gathered together in a natural amphitheatre formed by the hills, and on a day when the atmosphere was at rest.

Let us take a small platform arranged for an open-air speaker, and notice how an audience will form itself about it. If the audience is large and each person anxious to hear, we shall find that the outline of the crowd will be that of a section cut through an egg, with the speaker placed at the focus of the smaller end. As in an auditorium we trust to the natural diffusion of sound to absorb the stray rays, we should evidently adopt this same ovate section for the outline of the floor.

But, when we come to consider further that it is desirable to place each member of the audience so that he can see the speaker, and so that the speaker's voice may come directly to him, we see that we conform still further to the egg-shape, for, in order that we may do this, the floor must curve upward as it recedes from the speaker, and the galleries form only a continuation of this curve. To that we may say that the proper shape of an auditorium is in general that of an egg-shell, the speaker being at the focus of the smaller end and the audience being seated over the lower half, while the upper half forms the vaulted roof. Like an egg-shell, we have seen that the walls should be thin and capable of absorbing, as fully as possible, all the stray rays of sound. While the egg-shape is the ideal, other considerations fre-

quently require considerable departures, but it will generally be found that rooms constructed on this plan, if the materials of the walls and the condition of the contained air be secured, are acoustically good.

The Greek and Roman amphitheatres, having the audiences arranged in semicircles, each circle rising above the one in front of it, and having the auditorium either open at the top or covered with awnings so that the waste sound might easily escape at the top or be absorbed by the audience around the sides, were crude approaches to this plan. The modern theatres, in which the floor slopes upward as it recedes from the stage, and in which the balconies are placed one above the other and are of horseshoe form, conform still more closely to it.

Other considerations frequently demand that music-halls and churches shall be square or oblong in shape, and it must not be supposed that acoustic success can not here be obtained. But, in these forms, great care must be taken to avoid large reflecting surfaces, and, by means of paneling or other devices, to absorb fully the waste sound.

We have now examined the two important features on which acoustic success depends. The atmosphere must be in such condition as to best allow the natural diffusion of sound ; and, further, the walls must be of such material, and so arranged, as to absorb as fully as possible the waste sound. It now remains for us to look at some of the minor points which contribute to acoustic success.

There is one danger to which buildings having a vaulted roof are peculiarly liable, and that is, that the roof, if constructed of proper curvature and of non-absorbing material, is apt to act as a great concave mirror to gather up waste rays of sound and reflect them back to a focus somewhere in the audience, and so produces a loud and disagreeable echo. The architect can not exercise too great care in selecting absorbing materials, and in so arranging them as to prevent this possibility. A change in curvature, or breaking by transverse arches, will often do this. This focus would be a small area in case of a dome ; but, in case of an arched roof running from front to rear, it would be a straight line.

It often happens that churches constructed without regard to acoustic principles are found, when completed, to possess this fault in a striking degree. The only complete remedy in such cases is to entirely replace the ceiling. It may, however, often be largely alleviated by placing the pulpit in a different position, as near one corner or against the wall half-way down one side. Sometimes the fault may be largely remedied by using a reflector to throw the sound out toward the audience and prevent its going up toward the roof.

Reflectors, or sounding-boards, should be used only with judicious care. Their object is not, like a concave mirror, to gather the rays of sound and throw them out to a focus in the audience. When so constructed they have been found to do more harm than good, especially

when the focus is so distant that a strong echo is returned from the opposite wall. Their object is rather to control such rays of sound as would otherwise go up to the roof and be retained as a disagreeable echo. A perfectly flat surface placed over the pulpit and not too far from the speaker's head, will often do this; but it is better to have the wall back of the pulpit gradually curve forward until it completely overhangs the speaker's head. The speaker must be near to this wall, so that the direct and reflected sounds may be as nearly as possible identical.

There is a belief, prevalent among some architects, that a hall, in order to be acoustically good, must have its length, breadth, and height in harmonic proportion. There seems to be no good foundation for this belief, and the author, after careful experimental inquiry, has failed to find that this is the case.

It frequently happens that, in a building in which there is considerable resonance, the speaker, by timing his syllables so that the resonance of one shall have disappeared before the next is uttered, may make himself understood to a large audience with comparative ease. This is recognized by most public speakers, and it is not uncommon to hear them speak of the "key-note" of any particular hall.

The act of striking the "key-note" consists not so much in pitching the voice at any particular key as in carefully timing the rate at which the syllables succeed each other.

PROGRESS OF THE GERM THEORY OF DISEASE.*

By JOHN TYNDALL, F.R.S., LL.D. (M.D., TÜBINGEN).

THE virtual triumph of the antiseptic system of surgery, based as that system is on the recognition of *living contagia* as the agents of putrefaction, is of good augury as regards the receptivity of the public mind to new views respecting the nature of contagia generally.

To the credit of English surgeons it stands recorded that, guided by their practical sagacity, they had adopted in their hospitals measures of amelioration which reduced, almost to a minimum, the rate of mortality arising from the "mortification" of wounds. They had discovered the evils incident to "dirt"; and, by keeping dirt far away from them, they had saved innumerable lives, which would undoubtedly have succumbed under conditions prevalent in many of the hospitals of Continental Europe.

In thus acting, English surgeons were, for the most part, "wiser than they knew." Their knowledge, however momentous in its prac-

* Introductory Note reprinted from Professor Tyndall's "Essays on the Floating Matter of the Air, in Relation to Putrefaction and Infection."

tical applications, was still empirical knowledge. That dirt was fatal they had discovered; but why it was fatal few of them knew. At this point Lister came forward with a scientific principle which rendered all plain. Dirt was fatal, not as dirt, but because it contained living germs which, as Schwann was the first to prove, are the cause of putrefaction. Lister extended the generalization of Schwann from dead matter to living matter, and by this apparently simple step revolutionized the art of surgery. He changed it, in fact, from an art into a science.

"Listerism" is sometimes spoken of as if it merely consisted in the application of carbolic-acid spray; but no man of any breadth of vision will regard the subject thus. The antiseptic system had been enunciated, expounded, and illustrated, prior to the introduction of the spray. The spray is a mere offshoot of the system—elegant and effective it is true, but still a matter of detail. In company with my excellent friend Mr. John Simon, I once visited St. Bartholomew's Hospital, and became acquainted, in its wards, with the practice of the late Mr. Callender. The antiseptic system was there as stringently applied as at King's College. Immediately before his departure to America I spoke to Mr. Callender on this subject; and he then told me expressly that his aim and hope had been, not to introduce a new principle, but to simplify the methods of Lister. And yet Mr. Callender's practice is sometimes spoken of as if it were, in principle, different from that of his eminent contemporary.

It is interesting, and indeed pathetic, to observe how long a discovery of priceless value to humanity may be hidden away, or rather lie openly revealed, before the final and apparently obvious step is taken toward its practical application. In 1837 Schwann clearly established the connection between putrefaction and microscopic life; but thirty years had to elapse before Lister extended to wounds the researches of Schwann on dead flesh and animal infusions. Prior to Lister the possibility of some such extension had occurred to other minds. Penetrative men had seen that the germs which produce the putrefaction of meat might also act with fatal effect in the wards of a hospital.

Thus, for example, in a paper read before the British Medical Association at Cambridge in 1864, Mr. Spencer Wells pointed out that the experiments of Pasteur, then recent, had "all a very important bearing upon the development of purulent infection and the whole class of diseases most fatal in hospitals and other overcrowded places." Mr. Wells did not, as far as I know, introduce any systematic mode of combating the organisms whose power he so early recognized. But, I believe, in hardly any other department of surgery has the success of the antiseptic system been more conspicuous and complete than in that particular sphere of practice in which Mr. Wells has won so great a name.

A remark in the paper just referred to would seem to indicate that, in regard to the further possible influence of germs, the thoughts of Mr. Spencer Wells had passed beyond the bounds of pure surgical practice. "Their influence," he says, "on the propagation of epidemic and contagious diseases has yet to be made out."

This shows that at the time here referred to the germ theory, in its wider medical sense, had begun to ferment in England. Two years, indeed, prior to the above occasion, and for the use of the same Association as that addressed by Mr. Wells, the late Dr. William Budd had drawn up a series of "Suggestions toward a Scheme for the Investigation of Epidemic and Epizoötic Diseases," which strikingly illustrate the insight of a man of genius, withdrawn from the stimulus of the metropolis, and working alone, at a time when the whole medical profession in England entertained views opposed to his. Budd states in succession, and with perfect clearness, the points which he considers most worthy of the attention of the Association. He recommends inquiry as to the nature of the evidence alleged to prove the disease under investigation to be contagious or communicable. Whether such disease admits of being artificially propagated by inoculation or otherwise. Through what surface or surfaces the virus may be shown to enter the body, and to leave it, when the disease is taken in the natural way. Whether the disease is distinguished by eruptions external or internal. Whether it has a period of true incubation; and, if so, what are the length and limits of that period. Whether one attack, as in small-pox and many other contagious diseases, preserves against future attacks. Whether in the case of human disease animals as well as man are susceptible, and, if so, what animals. What is the evidence, if any, as to the particular country or region in which the disease first appeared? What are its present geographical limits? Whether there is any evidence of its modern or recent introduction into countries previously exempt. How far any such disease may have been prevented from invading new countries, or from spreading from any particular center, by measures directed against contagion. Above all, to determine what is the nature, and what the true value, of the evidence supposed to show that the specific poison of a contagious disease may originate spontaneously, or be generated *de novo*. "What we most want to know," adds Budd, "in regard to this whole group of diseases is, *where and how the specific poisons which cause them breed and multiply*."

Budd's own relation to the question here raised was distinct, and, under the circumstances, impressive. "After giving many years of time and thought to an examination of the evidence bearing on this question," he comes to the conclusion that "there is no proof whatever" that the poisons of specific contagious diseases ever originate spontaneously. "That the evidence on which the contrary conclusion is founded is negative only; that evidence of precisely the same order,

only to all appearance still more cogent, would prove animals and plants, even of large species, to originate spontaneously; that this evidence is therefore of no weight; and, lastly, that all the really important facts point the other way, and tend to prove that these poisons (to use a term which is probably provisional only), like animals and plants, however they may have once originated, are only propagated now by the law of continuous succession."

The word "poisons," here provisionally employed, was a concession on Budd's part to his weaker brethren; for he, without a shade of doubt, considered the poison to be a real living *seed*. There was, I believe, but one physician of eminence in England who, at the time here referred to, shared this conviction, and who imparted to Budd the incalculable force derived from the approbation and encouragement of a wise and celebrated man. It gives me singular pleasure to write down here the name of the venerable Sir Thomas Watson, who lent to William Budd unfailing countenance and support, and who has lived to see that the views which commended themselves to his philosophic judgment are at the present moment advancing with resistless momentum among the members of the medical profession. It was far otherwise at the time to which we here refer. "Opinions like these," said Budd, "are no doubt, at present, those of a small minority. A very large, and by far the most influential school in this country—a school which probably embraces the great majority of medical practitioners, and the whole of the 'sanitary public'—holds the exact contrary; and teaches that sundry of these poisons are constantly being generated *de novo* by the material conditions which surround us."

Budd's remark regarding the spontaneous generation of "animals and plants, even of large species," is both pregnant and pertinent. In reference to special and solitary outbreaks of contagious fever, I have frequently heard physicians of distinction affirm, without apparent misgiving, the "impossibility" of importation from without. On such occasions a reply, in the strict sense affirmed by William Budd, was always at hand; for I was able to adduce cases of solitary mushrooms, found upon out-of-the-way Alpine slopes, to which the evidence would apply with greater force than to the cases on which the physicians referred to based their conclusions. With the atmosphere as a vehicle of universal intercommunication, it is hard to see any just warrant for the reliance of medical men upon the negative evidence stigmatized by Budd as valueless. It is, however, evidence by which many physicians are still influenced, and the effects of which it will probably require a generation of doctors, brought up under other conditions of culture and of practice, to wholly sweep away.

These conditions are growing up around us, and their influence will be all-pervading before long. Never before was medicine manned and officered as it is now. To name here the workers at present engaged in the investigation of communicable diseases would be to ex-

tend beyond all reasonable limits this Introductory Note. On the old Baconian lines of observation and experiment the work is carried on. The intercommunication of scientific thought plays here a most important part. It will probably have been noticed that, while physiologists and physicians in England and elsewhere were drawing copiously from the store of facts furnished by the researches of Pasteur, that admirable investigator long kept himself clear of physiology and medicine. There is, indeed, reason to believe that he was spurred on to his most recent achievements by the papers of Burdon Sanderson, Koch, and others. The union of scientific minds is, or ought to be, organic. They are parts of the same body, in which every member, under penalty of atrophy and decay, must discharge its due share of the duty imposed upon the whole. Of this "body," a short time since, England provided one of the healthiest limbs; but round that limb legislation has lately thrown a ligature, which threatens to damage its circulation and to divert its energies into foreign channels. In observational medicine one fine piece of work may be here referred to—the masterly inquiry of Dr. Thorne Thorne into the outbreak of typhoid fever at Caterham and Redhill. Hundreds were smitten by this epidemic, and many died. The qualities of mind illustrated in Dr. Thorne's inquiry match those displayed by William Budd in his memorable investigation of a similar outbreak in Devonshire. Dr. Budd's process was centrifugal—tracing from a single case, in the village of North Tawton, the ravages of the fever far and wide. Dr. Thorne's process was centripetal—tracing the epidemic backward, from the multitude of cases first presented, to the single individual whose infected excreta, poured into the well at Caterham, were the cause of all.

The essays here presented to the reader belong to the A B C of the great subject touched upon in the foregoing Note. The two principal ones, namely, Essays II and III, were prepared for the Royal Society, and are published in the "Philosophical Transactions" for 1876 and 1877. But, though written for that learned body, I sought to render their style and logic so clear as to render them accessible to any fairly cultivated mind. The essays on "Fermentation" and "Spontaneous Generation" have already appeared elsewhere; while the first essay, on "Dust and Disease," has been for some years before the public. It may be regarded as a kind of popular introduction to the more strenuous and original labors which follow it.

The essay most likely to try the reader's patience is Number III. On the whole, however, and particularly in its bearings on the germ theory of disease, it is probably the most important of all. The difficulties which sometimes beset the experimenter in these investigations are best illustrated by this essay. It shows, to my mind in a very impressive manner, the analogy of the spread of infection among organic infusions with its mode of propagation among human beings.

The vital resistance of certain germs to heat is strikingly illustrated in the third essay, one infusion being there proved to maintain its potentiality of life intact after eight hours' continuous exposure to the temperature of boiling water. Under the plain guidance of the germ theory, it is, however, shown that an infusion of this stubborn character may be infallibly sterilized by discontinuous heating, in one hundredth part of the time requisite when the boiling is continuous. Another question, to my mind of fundamental importance, is also disposed of in Essay III, where it is shown that the germs which exhibited the foregoing resistance are neither contained in the air, nor attached to the surface of the vessel, above the liquid, but that they manifest their extraordinary vitality in the body of the liquid itself.

On public sympathy the sanitary physician has mainly to rely for support, in a country where sanitary matters are left so much in the hands of the public itself as they are in England. But sympathy without cause—that is to say, without some basis of knowledge—is hardly to be expected. It is as a contribution to such knowledge that these essays have been collected, and thrown into their present handy form.

ROYAL INSTITUTION, *August*, 1881.

A GIGANTIC FOSSIL BIRD.

BY STANISLAS MEUNIER.

THERE are really privileged persons within the scientific domain. M. Gaston Planté, whose name is associated with a most important advance in electrical knowledge, enjoyed the opportunity, in 1855, of making, in a wholly different direction, a discovery in paleontology that was of great interest. In a very curious bed of loam of the Eocene tertiary formation, called the ossiferous conglomerate of Meudon, and which has now nearly disappeared, he found a bird's tibia, which measured, though it was not whole, forty-five centimetres in length. At first sight this great bone appeared to exhibit considerable analogies with the corresponding part of the swan, and differed from it only by the presence of the subtrochlean groove, and by the relatively high situation of the osseous arch, and the outer muscular attachment. But what a contrast in the size! An idea of it may be gained from Fig. 2, A and B, which represent the tibia of the Meudon bird—to which Constant Prevost fittingly gave the name of *Gastornis* (Gaston's bird)—and the tibia of the common swan, on the same scale.

After M. Planté's discovery, a geological formation corresponding exactly with the conglomerate of Meudon was found at Reims. Quite recently, Dr. Lemoine has established the connection between the beds

of Reims and Meudon more closely by the discovery of the remains of gastornis in Champagne, from which he has constituted a new species that he calls *Gastornis Eduardsii*. The bird was not less than three metres (about ten feet) high when standing, and is shown in that position in Fig. 1. The author possesses the femur, the tibia, the tarso-metatarsian, and several phalangeal bones of this bird. The pelvis is represented in his collection by an ischion and the upper extremity of the pubis. A cervical vertebra, a caudal vertebra, a fragment of the sternum, and ends of the ribs, have furnished him subjects for interesting observations. Dr. Lemoine has collected pieces of bone, which he considers half of a breast-bone and a coracoid bone. He also describes the lower end of the humerus, a radius, a metacarpian, and the terminal phalangeal of the wing. A large proportion of the bones of the head have also been found by the author during his paleontological probings, and with their aid he is able to complete the description of this remarkable ornithological type.

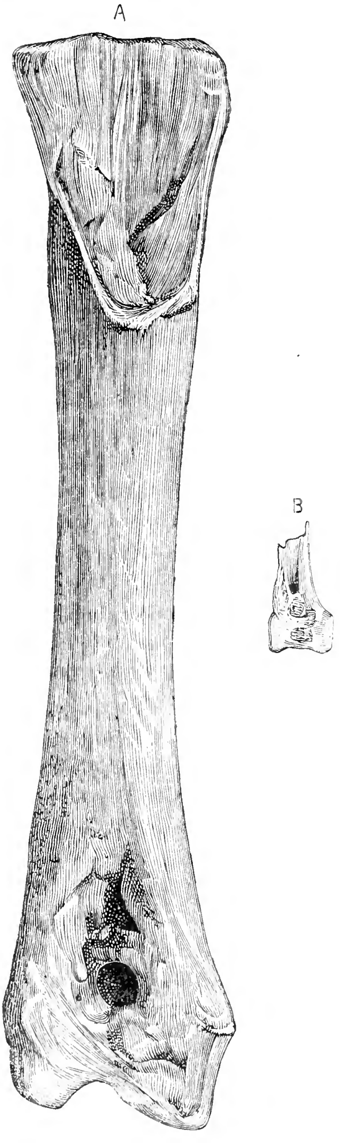


Fig. 2.—A, Tibia of the Gastornis of Meudon (reduced to one third of the natural size). B, Tibia of the Common Swan (reduced to one third of the natural size).

All the parts of the skeleton so far discovered are represented in Fig. 1, where they have been so placed as to show the skeleton restored, in its normal position.

This richness of his material has enabled Dr. Lemoine to form very precise notions concerning the giant bird of the environs of Reims. In his opinion, the cranium must have been relatively voluminous and less disproportionate than the cranium of the ostrich. This is indicated by the quadrate bone, a part of the orbitary cavity, and almost the whole of the base of the cranium, in which the occipital condyle, the sub-condylian furrow, the basilar tuberosities, the

sphenoidal escutcheon, and the basipterygoid apophyses with their faces well accentuated, are exhibited. According to Mr. Huxley, this

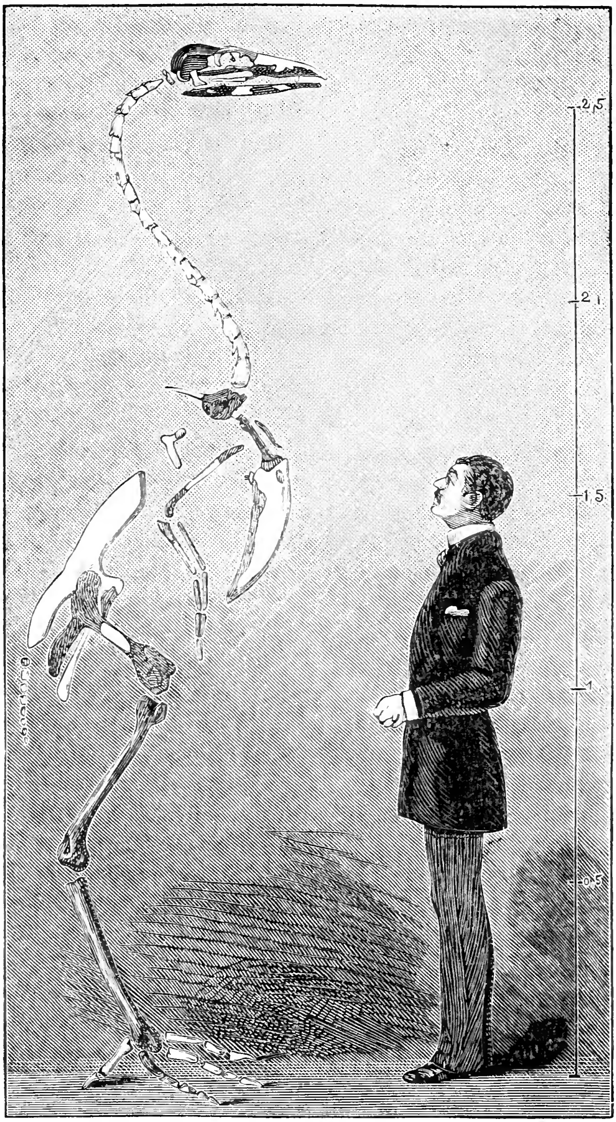


FIG. 1.—RESTORATION OF THE SKELETON OF GASTORNIS EDUARDSII, AN EOCENE BIRD, THREE METRES (or about ten feet) HIGH.

character occurs now with several birds—divers, ducks, and hens—and with several lacertians and ophidians.

The upper mandible, which was found almost entire, is very remarkable for a series of false alveoles, reminding one of the atrophied

alveoles of reptiles, and which probably corresponded, not with true teeth, but with thickenings of the horn of the bill. The bill also, toward its anterior third, seems to have represented a real tooth, but a tooth of a bony nature and of continuous substance with the bill itself. This mode of dentition had been previously observed by Richard Owen in the *Odontopteryx toliapica*.

The lower mandible is marked by its terminal extremity, which seems to have been slender, and by its hinder half presenting faintly-accentuated muscular attachments.

A part of the sternum does not permit us to say whether that portion of the skeleton had a keel. The shoulder seems to have been composed of a quite short breast-bone with a wide posterior articular surface, of a coracoid bone and of a scapulum, the group isolated and quite different from the single bone of the ostrich. The humerus is, like all the other bones of the wing, more voluminous than in the ostrich. The cubitus rather recalls the shape of that bone in ordinary birds, and bears marks indicatory of feathers. The radius was thin, the metacarpians appear to have been independent, offering a characteristic of great value, for it occurs only in two other orders. The iliac bone, very distinct, is remarkable for the sloping character of its posterior border. It is very difficult in the face of such characteristics to fix the true affinities of the gastornis. MM. Hebert, Ed. Lartet, and R. Owen, have expressed opinions on this point, and the latter is inclined to refer the fossil bird to the order of the waders, and more especially to the rails. M. Alphonse Milne-Edwards is of a different opinion, and is rather disposed, on the ground of a variety of osteological traits, to classify the gastornis with the ducks. But he is prompt to recognize that the Eocene animal offers peculiarities so different from anything shown in living nature that it is impossible to place the gastornis in any of the established natural groups. Another gastornis has been found at Reims, which Dr. Lemoine has described under the name of *Gastornis minor;* and the author has besides found the remains of two entirely different genera of birds.—*Translated from La Nature.*

THE BOOK-MEN.

By the late Hon. T. WHARTON COLLENS.

WHAT a vast difference there is between us and our ancestors who lived three thousand years ago! What savages they were! What a polished people are we! Surrounded by all the glories and lights, blessings and hopes of civilization, we can hardly realize the fact that we are the descendants of men who roamed in

forests and deserts, of men as ignorant, superstitious, wild, and brutal as the Comanche Indians. Such, nevertheless, is the fact; and the question naturally arises: How, through the ages, have our ancestors been able to overcome their abject condition, and rise to the heights of knowledge and art, to survey an immense horizon of truth, and use the magical bounties of invention? Did the light break upon us all at once; did we get all the superior advantages of science and art we now enjoy from a single hand or from one inspiration, or was the process not only slow and gradual, but difficult and terrible? To what or to whom do we owe this great change, this wonderful transformation of the mind, manners, and labors of the human race?

We answer at once: The progress of man from the savage to the civilized state of society and to its functions and uses was indeed slow and arduous, and is due to the studies of solitary, thinking book-men, careful theorists, or inquisitive philosophers, who, in each generation, and one after the other, have promulgated the result of their meditations.

Understand us—we mean what we say: we say *book-men*, we say *theorists;* and, if humor prompts, it may add contemptuous epithets to the terms. We may say, if we choose, *mere* book-men, *mad* theorists, or *dreamy* philosophers, and still the proposition would be true.

To demonstrate this truth we might begin with primeval man, go through ancient history, tracing the march of mind from the mythic Hermes of Egypt, the Pythagoras of Greece, the Zoroaster of Persia, to the grand display of civilization exhibited by the Roman Empire under Aurelius Antoninus, or under Constantine the Great, and thence follow the current in all its vicissitudes down to the present age. But the limits of a single article preclude so extended a review of human progress. Hence, we are compelled to select, if possible, a period of history within which a fair illustration of the march of mind may be found (leaving out former and subsequent ages), to test other periods by the same laws of development. Let us, therefore, begin in the middle of the middle ages, that is to say, in the year 800 after Christ, and finish with the discovery of America, in the fifteenth century. From this first point our premises will be apparent. At the last point our conclusion will be reached; and then all the consequences, as applicable to modern times, will show themselves as clearly as the landscape in the light of day.

In the year 800 after Christ, what was the state of Europe? The Goths, the Vandals, the Franks, the Huns, the Normans, the Turks, and other barbarian hordes, had invaded and overthrown the Roman Empire, and had established various kingdoms upon its ruins. These hordes of savages had destroyed, not only all the works of civilization, but civilization itself. Ignorant as they were of everything that distinguishes and elevates human nature, they broke up the schools, ruined the monuments, abolished arts and manufactures, prevented commerce,

and reduced the conquered nations to their own condition, inaugurating in the completest manner the reign of brute-force and mental darkness. If they afterward espoused Christianity, they molded it to their own savage superstition, till at last naught was left of the divine dispensation but its name, to cover the most degrading idolatry and demonism. At the time we begin our specific examination we find that, in the then so-called Christian nations—

1. There existed no science worthy of the name, no schools whatever. Reading, writing, and ciphering, were separate and distinct trades. The masses, the nobility, the poor and the rich, were wholly unacquainted with the mysteries of the alphabet and the pen. A few men, known as *clerks*, who generally belonged to the priesthood, monopolized them as a special class of artists. They taught their business only to their seminarists, apprentices ; and beyond themselves and their few pupils no one knew how to read and write, nor was it expected of the generality, any more than it would be nowadays, that everybody should be a shoemaker or a lawyer. Kings did not even know how to sign their names, so that when they wanted to subscribe to a written contract, law, or treaty, which some clerk had drawn up for them, they would smear their right hand with ink, and slap it down upon the parchment saying, "Witness my hand." At a later date, some genius devised the substitute of the seal, which was impressed instead of the hand, but oftener besides the hand. Every gentleman had a seal with a peculiar device thereon. Hence the sacramental words now in use, "Witness my hand and seal," affixed to modern deeds, serve at least the purpose of reminding us of the ignorance of the middle ages.

In fact, in those days a nobleman considered it below his dignity to have any knowledge of letters. This was left to persons of inferior rank. The use of arms, horsemanship, and war, were the sole avocation of the lords of the land. As all authority, and indeed safety, depended upon force and success in battle, skill at arms was necessarily the genteelest of the arts. The nobility knew no other ; and the workmen they admired the most were those who forged their uncouth armor, ungainly shields, and clumsy swords.

Society was divided into orders : at the top were the prelates and priesthood, the kings and nobles ; at the bottom the serfs who were the bulk of the people ; and intermediate were a few free workmen and burgesses who enjoyed a sort of *quasi* exemption from personal servitude, but were subject to the despotic rule of the king and lords.

All persons were also unmitigated believers in magic, sorcery, witchcraft, enchantments, amulets, astrology, evil-eye, conjuration, fascination, divination, fetichism, charms, evocation of ghosts, specters and devils, talismans, incantations, fortune-telling, palmistry, cabalistic arts, spells, divining-rods, bargains with the occult powers, and the

like. Even in our time vestiges of the like belief exist among us, but then it was universal and denied by none, whether prince, priest, or populace. There is no parallel to this state of things in modern times, except in the interior towns of Africa.

It was then universally conceded that the nobles were men of a superior race; that their blood was different and purer than that of other men. All the land belonged to them. No one doubted their title. The population of every barony considered the baron as their rightful master, holding his authority from God himself. It was next to sacrilege to disobey him. Yet these barons were brutal, extortionate, and cruel. They were constantly at war with each other, and therefore lived in fortified castles, whence they now and then sallied to levy contributions among their own serfs, rob passengers and caravans on the highway, or plunder and burn the property or massacre the people of neighboring fiefs. They had the right of life and death over their vassals. These could not marry or travel without their permission. The maidens of the baronies were obliged to gratify the lusts of the baron whenever he took a fancy to any of them; and this, so far from being considered as an act of outrageous despotism, was generally accepted as an honor conferred. No Turkish pasha or Russian boiar holds now greater power than the feudal lords possessed and abused during the middle ages. They exacted and took the first, the largest, and the best products of the labor of the people; and none (not even those who were the victims of unscrupulous tithes, tribute, and pillage) ever suspected that the nobles exceeded their divine and rightful privileges. The people, when robbed, or put to the rack, might think their lord was a hard and cruel master; but his right to do as he pleased was to every mind unquestionable.

The laws which then existed (if indeed the name of law could be justly applied to such an ordination of society) were only such as were calculated to maintain the power and fortune of the tyrants we have just described. Murder was punished only when the culprit was a villain, or a man of inferior rank to that of his victim; and then the punishment was graded, so that the murder of a noble or priest by a villain or inferior was avenged by the most revolting and agonizing tortures and death, while, if on the contrary the victim was a villain and the homicide a nobleman, a few pence was the price of blood. Trials there were none worthy of the name. They tested the guilt or innocence of those who were suspected of offenses by various superstitious practices, such for instance as making the supposed offender walk over red-hot plowshares. If he got burned he was guilty, if he passed over unscathed he was innocent. The favorite mode of deciding causes before the courts was the trial by battle. The parties were made to fight it out, but not always with equal arms. The villains were permitted only to wield the club, while the gentry entered the lists sword in hand, clothed in armor and on horseback.

The result of the combat was religiously believed to be "the judgment of God" between the parties.

We have said that in those ages no science existed. Let us add that it was then universally taken for certain truth that the earth was flat; that the skies were a dome of hard adamant, which inclosed and covered the world like the walls and roof of a building; that the stars were occult beings having good or evil influences over men; that the winds and the floods, the rain and the crops were either special dispensations of Providence, independent of any original design or law, or were, when unfavorable, the act of evil spirits or magical operations. The monuments of Roman architecture were allowed to go to ruin. The art of building had been almost forgotten, and was limited to the erection of rough and uncouth fortresses and walls suited to keep men and horsemen at bay. These were usually located on the tops of almost inaccessible rocks. The people lived in huts; they ate with their hands; food was cooked without pots or kettles, on the embers, or roasted on spits. Candles were unknown, stockings were unknown, clothing was made of dressed skins, and, though some woven fabrics were made by means of hand-looms, they were so inferior that the ordinary stuffs worn by the people of the present day would have been then considered as luxurious finery fit for a king to wear.

We forgot also to mention, in relation to the trial by battle, that the lawyers of those days did not gain their suits by means of evidence, authorities quoted out of books, and speeches or arguments addressed to the courts; but the lawyers were men-at-arms, expert in the use of the sword, the lance, the mace, and the *bâton*; and the parties, when they were able, would hire them to fight out the case in the arena as gladiators. Thus the case would be decided in favor of him whose lawyer beat, or cut down, or unhorsed his adversary's lawyer. Those were indeed the days when might was right.

Our object in giving this sketch of the state of civilization in the eighth and ninth centuries is, to contrast the condition of society then with what it is now, and to inquire how mankind could emerge from that order of things to the present stage of human progress. By what means were barbarism, universal ignorance, and superstition to be overcome? From whom was the first light to come? Who was to take the first step toward a better order or higher knowledge?

The impediments were of the most formidable character. Everybody was ignorant except the few *clerks*, or clergymen, we have mentioned, and even the range of their knowledge, beyond theology, was very limited. All around them was darkness, and naught indicated even a gleam of light or liberty.

By whom or when was the first step taken? By the very clerks or book-men we have mentioned, during the reign of Charlemagne in France, and that of Alfred in England. Long had they labored in the solitude of their cloisters to enlarge the scope of their learning. As-

siduously had they multiplied copies of precious manuscripts and of their own works. Zealously had they striven to find laymen willing to purchase and study those works and listen to their instructions. At last they persuaded Charlemagne to establish a school in Paris, and Alfred to found a university at Oxford, in order to educate aspirants for the priesthood and form doctors of theology. Nothing was thought of but to cultivate the kind and extent of learning then existing. It was natural to procure for these schools copies of all the books then to be found. Few, indeed, were these—as brief sketches of Latin grammar, a few Latin vocabularies, a meager treatise on arithmetic and geometry, and a stray copy of the philosophical work by Porphyry, and another by Boetius. The rest was all Christian theology and philosophy, such as the works of St. Augustine and other fathers, besides the Bible and the canons of the Church. The *savant* chosen for Paris was the monk Alcuin, and the scholar selected for Oxford was another monk, Grimbaldus.

The deed was done. A school was established. Men were offered a great opportunity of becoming book-worms, and consequently to think and theorize. The result was inevitable. To meditate, they had to exercise their reasoning faculty, while they studied the philosophy they found in the few books they had, and pondered over theology, theology and ancient philosophy as harmonized with dogma.

One of the teachers who succeeded Alcuin was a doctor of philosophy named John Scotus Erigenus, an Irishman by birth. He wrote philosophical treatises in which a new question was raised. This question was, whether an abstract term or a word, such, for instance, as the word "*humanity*," represented a real being; an essence in nature; a real and single thing existing independent of any individual. Not whether there were many individual men included by a process of thought under a general name, but whether that general name "humanity" was not the name of a *reality*, antecedent in creation and in time to the existence of any individual—antecedent to Adam himself.

Vain as this question would seem, it raised a great debate among the clerks and doctors. Soon parties were formed among them, *pro* and *con*. The one party got the name of Realists, the other that of Nominalists. Minds became excited, curiosity was aroused. In order to prove one opinion or the other, information was sought in every direction. Every scrap which could be found of Plato's and Aristotle's works was rescued from oblivion, and quoted as authority by one or the other side. Other ancient books were disinterred. The *savants* began to investigate natural phenomena, and, above all, to closely scrutinize man himself, physically and intellectually.

Though the question in debate might appear at this day quite frivolous and easily answered, yet in those times it was necessary as a first step in the progress of getting rid of the fundamental errors and

prejudices prevalent even among the *savants*. We must not lose sight of the mental condition of all men in those times. If we keep this in view, we shall, instead of despising the men who first put the question just stated, wonder how at that stage of intellectual progress it could have suggested itself to any mind. Certain it is that the most learned (so small was their amount of science, and so peculiar were the settled opinions of their age) were not ready to discuss other subjects.

They soon brought their discussions before their pupils, and from among these the debate found its way into society: kings, nobles, and burgesses talked about it, and as a consequence talked about the points of knowledge necessary to solve the question. This was a slow operation indeed. It took eight centuries before the controversy was settled.

Yet, in time, hundreds of other questions grew out of this single one, and it became necessary to settle all the minor objections and issues before the main one could be concluded upon. What is soul? what is mind? what is reason? what is feeling? what is sensation? what is knowledge? what is man and his destiny? what is revelation in contradistinction to science? how far can science go without requiring the aid of revelation? is man a free agent? are all men of the same species? what are the laws of thought?—in one word, what was true or not true in everything then generally held to be true?

We are far from wishing it to be understood that all these questions were immediately suggested or started; but the book-men (as their sphere of thought became more and more enlarged) by the sharp contradiction of one another, found it necessary to suggest and discuss them all. They did so boldly and conscientiously, in their contestations. They did so, though many among them were, for the anti-Christian opinions they advanced, condemned as heretics.

But we are too hasty. We must endeavor to show the different steps of this evolution, and the main instrumentality of the book-men and the theorists in every advance that was made.

In the course of the reign of Charlemagne, the doctors of philosophy composed a calendar, and proposed the months as we have them now. This calendar they formed by means of their studies of such ancient writings of the Greeks and Romans as they had been able to procure.

They prevailed upon Charlemagne to establish this calendar by law. By doing this, Charlemagne got all the credit of the work itself; but to a certainty he was incapable of performing it. Individually, he was an ignorant man; but he thirsted for knowledge, glory, and power; had heard from the scholars of the ancient grandeur, monuments, and literature of Rome and Greece; and his ambition impelled him to carry into effect any suggestion of measures likely to contribute to his glory. He was devout, and sought also the glory of God.

Hence he encouraged education, for he found it furnished men capable of serving him effectually in all his aspirations. But who could give education? None but the clerks or book-men, who were then the only men of science.

Passing beyond this reign, we see the effects of this policy gradually developing themselves. During the tenth century, the arithmetical figures we now use to write down numbers were first introduced into Europe. Previously the Roman letters I, V, X, L, C, etc., had been employed to express numeric quantities. The advantage of the *new* method we can all appreciate, for it is the method we all use at present. But who first introduced and taught this improvement in arithmetical notation, with all the facilities it affords for the calculations? We owe the importation to the book-men who traveled to acquire knowledge from the Arabs who had conquered Spain, and whose schools at Cordova had acquired great celebrity. Thus we see the advance of science was from one set of book-men to another set of book-men, and from their schools to the people.

In this and the preceding century too, we find that it had become a common practice for the doctors of philosophy and theology to challenge each other to *public* debates; and that it became fashionable for the gentry to be present at these intellectual duels, where thought met thought in a struggle to convince of truths or convict of error.

From theologians arose the most distinguished philosophers of the times. We could, in our advanced state of knowledge, consider the scientific opinions they advanced as unworthy of our serious consideration; but then they were of the utmost importance, in this, that they were incitements to thought and to further investigation. This was the main thing in an age of intellectual obscurity, to bring forth more and more light from the first sparks of truth. The mind once awakened, curiosity and reflection once aroused, a process of development of right reason was inaugurated, which in time spread itself from the mind of man over all nature.

This takes place in the midst of the first Crusades, by which hundreds of thousands were led to perish disastrously; but restless and curious philosophers followed in the wake of war and rapine, and hovered around the armies to bring back from the East all the science they could gather. We often read of the improvement in science the West of Europe derived from the Crusades; but the story is always told so as to leave the impression that the plunder the mind brought back from Constantinople, Antioch, Jerusalem, and Alexandria, was gathered there by the boorish soldiers and their captains. A moment's thought will, however, set us right on this point. Science could only be gathered by men already partially acquainted with science, by men having a taste for it, by the scholars and the book-men. To them, therefore, must we award all the praise for any scientific advantage

which Europe derived from the Crusades. The armies were intent upon booty and power; the philosophers who followed them were seeking for new truths; and the advance of knowledge that they returned with is one of the benefits the West of Europe derived from the Crusades.

Let us note some of the most important prizes they carried home. At Amalfi, a port in the southern part of Italy, a stopping-place for the Crusaders, they discovered a copy of the "Institutes and Pandects of Roman Law," a work which had been long lost to the world. From the Arabians of Spain or Alexandria they procured the works of Plato and Aristotle, as well as other learned treatises of ancient sages. These they studied and commented on with assiduity, each one according to the bent of his mind. Hence, in time we find the learned men not only becoming numerous, but divided into classes. Some follow the study of religion, humanity, and mind; others devote themselves to history, grammar, and poetry; others to law; others to mathematics and astronomy, and others to architecture. But we must keep in view that all these sciences and arts were yet in a crude state, far, far beneath what they are at this day. The book-men, the theorists, the philosophers, had centuries of research, discussion, and reflection to accomplish, and numberless labors to undergo, before producing the good harvest we are now enjoying.

Thus, in the thirteenth century the book-men and their disciples, the lawyers, politicians, poets, painters, masons, astronomers, architects, navigators, physicians, and all other seekers and distributors of knowledge, had hosts of adherents among the masses. Hence, the practical results of the labors of the scholars were becoming more apparent.

In religion St. Thomas produces his "Sum of Theology," and brings the scholastic philosophy to its perfection. In politics, the yeomanry of England, instigated by Archbishop Langton, a book-man, demand and obtain Magna Charta—that is to say, no taxes without representation, trial by jury, *habeas corpus*, and no taxes without the consent of Parliament; while in Florence a democratic constitution is established by the people. In science, the labors of the alchemists and astrologers are progressing toward the first positive dawn of chemistry and astronomy; and Roger Bacon, the first of the great prophets of natural science, reveals some of the most important secrets of chemistry. Roger Bacon, the first of the natural philosophers, who was he? History answers—a book-man, a monk, a solitary student of the works of his predecessors in philosophy and theology. In the arts, Gothic architecture raises a worthy tribute to Heaven. We also find that in this century navigation begins to improve and commerce to be developed, particularly in England and in Italy; and the learned take advantage of the facilities thus afforded to undertake voyages in search of geographical and other knowledge. Among the rest, Marco Polo, a student of languages, travels throughout Asia, finds his way even to

China and Japan (a most wonderful feat in those days), and, on his return, writes an account of his travels; and his book, at a later day, serves (among other things) to induce the discovery of America by Columbus.

We now enter the *fourteenth* century, and amid the many practical consequences of the dissemination of knowledge from its original source, the book-men and philosophers, we might, unless we consider the necessity of the case, lose sight of the starting-point. In Spain, Alfonso the Wise gives his people the laws of the Seven Partides, compiled by philosophical jurisconsults from the Roman law. In France, the States-General, or Grand Parliament, is convoked by Philip le Bel, and, after him, Louis X makes the Parliament a permanent institution for the sanction of all laws. By-and-by the serfs and peasantry acquire their freedom and gain many valuable rights—not, however, without insurrection and bloodshed. Marcel in Paris and the Jacquerie in the provinces strike for liberty. In England the Commons assert their privileges: no money to government without their consent; the concurrence of the Commons with the Lords necessary for all laws; and the right of inquiry and impeachment by the Commons established. In Switzerland, William Tell leads his countrymen to victory and national independence and republican institutions. In Italy, the mariner's compass is invented by Gioja de Amalfi. Dante, Boccaccio, and Petrarch, those first lights of the dawn of polite literature, compose their beautiful romances and poems. In Germany clocks are invented, and Schwartz first puts gunpowder, invented by Roger Bacon, to practical use, and some scientific mechanic builds the first paper-mill. Previously manuscripts were all written on parchment. These were magnificent results, taking place in the midst of terrible persecution; but we understand it all when we know that in spite of every obstacle and opposition the book-men had, in this and the preceding centuries, unceasingly labored amid the capricious favors and disfavors of princes and kings to establish libraries, schools, and universities everywhere. They succeeded admirably, and every generation saw the increase of the number of those to whom the benefits of education had been communicated. Notwithstanding the fears of despots, the trial by ordeal began to fall into disrepute, the influence of the principles of the laws of ancient Rome as Christianized by Justinian was felt.

At last we reach the glorious fifteenth century, ever memorable for the invention of printing and the discovery of America. Why was printing invented? Because the demand for books had directed inventive genius to seek a substitute for the laborious and costly process of copying. Guttenberg, the inventor, was himself a lover of books and a scientific mechanic. Why was America discovered? Because schools of mathematics, astronomy, and navigation had been established at Genoa, in one of which Columbus was educated. Thence,

and in subsequent life, he derived the benefits of the labors of Lorenzo of Pisa, who had introduced algebra into the universities of Europe; and of Müller and Boehm, who had, by their geometrical researches and theories, demonstrated the rotundity of the earth. With this knowledge, confirmed by observation during his early life as a navigator, and the works of Marco Polo, Columbus projected the voyage which resulted in the discovery of the Western Continent. But printing and the rotundity of the earth were not the only consequences of the studies of book-men in the fifteenth century. We have already mentioned algebra, and have time only to state that the establishment of the first bank at Genoa, the Hanseatic League, the voyage of Vasco de Gama around the Cape of Good Hope, the first working of coal-mines at Newcastle, Norwich, the first drama, the final systematization of musical notation, all took place in the fifteenth century. We should also have shown how the study of æsthetical principles in this and the preceding century, by the societies and guilds of masons and architects, endowed the world with great painters and architects, and sculptors—Benvenuto, Raphael, Angelo, Titian, and many more who have left behind them imperishable monuments of their studies and genius.

Need we look back to recapitulate and confirm the fact that the highest source, continuous movers and central custodians of the studies which caused these great events were book-men, school-men, and theologists? Let us rather look forward into succeeding centuries, and merely mention the names of Erasmus, Thomas More, Francis Bacon, Descartes, Tycho Brahe, Kepler, Galileo, Newton, Dalton, Lavoisier, Shakespeare, Harvey. But no! the names of the studious thinkers who from their cabinets and laboratories have revolutionized the world, and to whom we owe the grand and beautiful civilization and works—arts, machines, products, conveniences, political science, liberty, commerce, etc., which we now enjoy, would take hours to enumerate. There is not a development of science or art that can not be traced back to the "*eureka*" of some solitary, plodding book-man.

ABOUT ELEPHANTS.

By Dr. ANDREW WILSON, F. R. S. E.

THE interest which attaches to the modern representatives of the mammoth host is by no means limited to the zoölogical world, but extends throughout all classes of society, who find something to wonder at even in the huge proportions and ungainly ways of the elephant family. A remarkably limited family circle is that which includes the elephants as its typical representatives. The past history of the race, like that of not a few other groups of animals and plants, is exactly the converse of its present-day phases, as regards numerical

strength at least. As the existing pearly nautilus is the sole survivor of the immense hordes of four-gilled and shelled cuttle-fishes which swarmed in the primitive seas and oceans of our earth, or as the few living "lampshells," or *Brachiopods*, represent in themselves the fullness of a life that crowded the Silurian seas, so the two existing species of elephants with which we are familiar to-day stand forth among quadrupeds as the representatives of a comparatively plentiful past population of these mammalian giants. The causes which have depopulated the earth of its elephantine tenants may be alluded to hereafter; but it is evident that neither size nor strength avails against the operation of those physical environments which so powerfully affect the ways and destinies of man and monad alike. One highly important feature of elephant organization may, however, be noted even in these preliminary details respecting the modern scarcity of elephantine species, namely, that the slow increase of the race, and, as compared with other animals at least, the resulting paucity of numbers, must have had their own share as conditions affecting the existence of these huge animals. The elephants are, of all known animals, the slowest to increase in numbers. At the earliest, the female elephant does not become a parent until the age of thirty years, and only six young are capable of being produced during the parental period, which appears to cease at ninety years of age; the average duration of elephant-life being presumed to be about a hundred years. But it is most interesting, as well as important, in view of any speculation on the increase of species and on the question of competition among the races of animal life, to reflect that, given favorable conditions of existence, such as a sufficiency of food, a freedom from disease and from the attack of enemies, and the elephant race, slow of increase as it is, would come in a few thousand years to stock the entire world with its huge representatives. On the data afforded by the foregoing details of the age at which these animals produce young, and of their parental period, it is easy to calculate that in from seven hundred and forty to seven hundred and fifty years, nineteen million elephants would remain to represent a natural population. If such a contingency awaits even a slowly increasing race such as the elephants unquestionably are, the powerful nature of the adverse conditions which have ousted their kith and kin from a place among living quadrupeds can readily be conceived. In the face of such facts, the contention that the "struggle for existence," in lopping off the weak and allowing the strong to survive, accomplishes in its way an actual good becomes clear. And the important biological lesson is also enforced, that there is a tolerably deep meed of philosophy involved in the Laureate's pertinent remark concerning the "secret meaning" of the deeds of Nature, through

> "finding that of fifty seeds
> She often brings but one to bear."

Reference has already been made to the paucity of existing species of elephants, only two distinct species being included in the lists of modern naturalists. These are the African elephant (*Loxodon* [or *Elephas*] *Africanus*) and the Indian elephant (*Elephas Indicus*). But the elephantine race is not without its variations and digressions from the ordinary type. We discover that among the elephants of each species "varieties" are by no means uncommon. These varieties appear as the progeny of ordinary animals. Thus the Sumatran elephant and that of Ceylon are regarded as constituting a distinct species, one authority (Schlegel), indeed, affixing to it the distinctive appellation of *Elephas Sumatrensis*. The balance of zoölogical opinion, however, is in favor of the Ceylon form being simply a "variety" of the Indian species; in other words, the differences between these two forms are not accounted of sufficient merit to elevate the former to the rank of a distinct animal unit. The famous "white elephants," whose existence has given origin to the proverbial expression concerning the disadvantage of unwieldy possessions, have a veritable existence. In Siam, as is well known, these animals are regarded with the utmost reverence, and are held in sacred estimation and kept in royal state by sovereign command. They are to be regarded, however, merely as an albino or colorless "variety" of the Indian species. Their production depends, like that of albinos or white varieties of birds or other animals, on some undetermined conditions affecting development. We occasionally find white varieties of birds—even including that paradoxical anomaly, a white blackbird—and albino cats are as familiar objects as are albino rabbits and white mice. Darwin remarks on the fact that albinism is very susceptible of transmission to offspring, and it is so even in the human race. It is not known whether the white elephants exhibit any special peculiarity of structure or life; but the interesting correlation has been observed that almost all white cats which possess blue eyes are deaf. The nature and origin of this association of characters are unknown, but the occurrence of such apparently unconnected states serves to remind us that great as yet are the mysteries which environ the becoming of the living worlds.

The characters of the Indian and African elephants, respectively, are by no means difficult to bear in mind. The Indian elephant (Fig. 1, 2) has a concave or hollow forehead, and the ears are of relatively moderate size. The eye is exceptionally small, while there are four nails or hoofs on the hind-feet, the number of toes on each foot being five in all elephants. The color of the Indian species is, moreover, a pale brown, and is of a lighter hue than that of the African species; and, while the former has "tusks" in the males alone, the latter possesses tusks in both sexes. The African elephant (Fig. 1, 1) has a rounded skull and a convex forehead, and the ears are of very large size. It possesses only three nails on the hind-feet, and four hoofs on

the front toes. Certain important differences, to be presently noted, also exist between the teeth of these species.

The limits of size of the two species of elephants appear to have afforded subject-matter for considerable discussion. The average height of the male Indian elephant is from eight to ten feet, and that

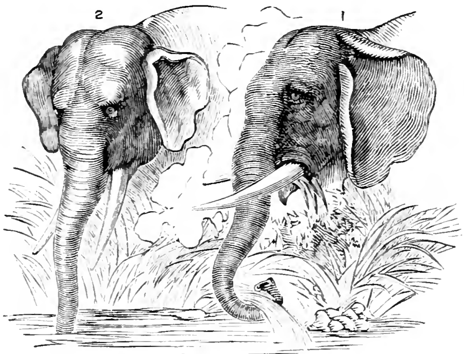


FIG. 1.—HEADS OF (1) AFRICAN AND (2) INDIAN ELEPHANTS.

of the females from seven to eight feet. The African species, according to the most generally recorded testimony, attains a larger size than its Indian neighbor. Sir Emerson Tennent, quoting a source of error in the measurement of elephants, gives the remarks of a writer who says:

"Elephants were measured formerly, and even now, by natives, as to their height, by throwing a rope over them, the ends brought to the ground on each side, and half the length taken as the true height. Hence the origin of elephants fifteen and sixteen feet high. A rod held at right angles to the measuring rod, and parallel to the ground, will rarely give more than ten feet, the majority being under nine."

As regards the number of elephants captured annually, a recent return gives us five hundred and three as captured in the three years ending 1880, in the forests of Assam, by the Indian Government.

There exist a few points in the special anatomy of the elephants of which it may be permissible to treat briefly, and, of these points, the skeleton presents several for examination. First in interest, perhaps, comes the enormous size of the skull, and the modifications wherewith this huge mass of bone is rendered relatively light and more easily supported on the spine. The skull of the elephant is unquestionably large, even when considered in relation to the huge body of which it forms such an important part; but, when the skull is seen in section, we discover that, instead of presenting us with a solid mass of bone, its walls are hollowed out in a remarkable fashion, so as to materially reduce its weight. It is evident that a demand exists in these animals for a skull of great strength, which not only shall be

equal to the task of giving origin to muscles of power sufficient for the animal's movements, but which may also adequately support the great "tusks." And Nature has succeeded accordingly, by a most interesting modification, in uniting size and strength to a minimum of weight.

A very short but strong neck and powerful bony processes borne on the joints thereof serve as support and holdfasts respectively for the huge cranium. In other parts of the skeleton, such as in the shape and form of the shoulder-blade, the elephants resemble the rodent quadrupeds, such as the hares, rabbits, rats, beavers, etc.; and it has long been a notable fact of elephantine anatomy that this resemblance is by no means limited even to the bones. But a somewhat ludicrous peculiarity of the elephants, readily noted by the observer, and one referred to by both classic and modern poets, is their awkward gait; and this again depends upon a readily understood anatomical modification. It is such a peculiarity that is referred to in "Troilus and Cressida," in the lines—

> "The elephant hath joints, but none for courtesy,
> His legs are legs for necessity, not for flexure."

And again the phrase—

> "I hope you are no elephant, you have joints,"

evidently refers to the curious and ungainly movements of these quadrupeds. The explanation of the elephantine gait rests primarily with the length of the thigh-bone, and with the facts that this bone is very long and lies perpendicularly to the line or axis of the spine, the thigh not forming an acute angle with the spine, as in other quadrupeds. Thus, the "ham" of the animal stretches half-way down the thigh, and, when the animal walks, the bend of the knee or leg at the latter point imparts a decided clumsiness to the gait. The great body rests, not so much upon the toes as upon the great pads which unite the toes, and which in fact constitute a broad, flat sole behind these members. Similar pads in the rhinoceros and hippopotamus support the weight of the body. No collar-bones are developed in the elephant race—a fact which, of course, bears a relation to the absence of those movements, such as climbing, etc., in which these bones play an important part, as serving to fix the limb employed. The brain of the elephant reveals certain points of anatomical interest. For example, the lesser brain or "cerebellum" is not covered by the brain proper or "cerebrum"; but the surface of the latter is deeply convoluted or folded. The existence of deep brain-convolutions in man is believed to be associated with a high measure of intellectual power, and the elephants do not seem to belie the statement, as applied to lower life, when their sagacity is taken into consideration. The proportion borne by the weight of the brain to that of the body has always formed an interesting topic of physiological nature. As a matter of fact, great varia-

tions exist when the ratio of brain to body is examined in different animals. Thus in man, as is the case with lower animals, the ratio diminishes with increasing weight and height. In lean persons the ratio is often as 1 : 22 to 27, and in stout persons as 1 : 50 to 100. In the Greenland whale the ratio is given as 1 to 3,000; in the ox as 1 to 160; in the horse as 1 to 400; in the dog as 1 to 305; in the elephant as 1 to 500; in the chimpanzee as 1 to 50; and in man as 1 to 36.

The absolute weight of brain in an elephant which was seven and a half feet high, and eight and a half feet in length from forehead to tail, was nine pounds. The brain of an Indian elephant was found to weigh ten pounds; and Sir Astley Cooper gives the weight of the brain of another specimen as eight pounds, one ounce, and two grains; while that of an African elephant seventeen years old was found by Perrault to weigh nine pounds.

The muscular system of the elephant necessarily partakes of the massive character adapted for the work of moving and transporting the huge frame. But the anatomy of the "proboscis" or "trunk" constitutes in itself a special topic of interest, and one, moreover, which gives to the proboscidian race one of its most notable characteristics. The "trunk" is, of course, the elongated nose of the elephant. It is perforated by the nostrils which open at its tip, and above the apertures is a curious finger-like process, which, when opposed to a small projection somewhat resembling a thumb in function, constitutes a veritable hand, and is utilized by the animal in almost every detail of its life. With the exception cf the snout of the tapirs, the trunk of the elephant has not even a distant parallel in the animal series. Its muscles form two sets of fibers, one set of which compressing its substance also extends its length, while the second set shortens the organ and enables it to bend freely in any direction. When we add to the possession of this extreme muscularity a high degree of sensitiveness, the proboscis of these animals may be regarded in the light of one of the most useful as well as most interesting features of their organization. Its use is not limited to the prehension of food (Fig. 2, 1, 2), however, or even to the additional function of an organ of touch. Occasionally, water is drawn up into the trunk, and is then squirted over the body as from a flexible hose (Fig. 2, 3), thus serving as a kind of shower-bath apparatus; and stories have been recorded wherein such a use of the proboscis has played a prominent part in the act of elephantine revenge on some over-bold or offending human.

The teeth of the elephantine race form a highly characteristic feature of their anatomy. In the mouth of a higher quadruped, such as man, the bat, or ape, no less than four kinds of teeth are represented. These are the front teeth, or incisors, the "eye-teeth," or canines, the premolars, and the molars, or "grinders."

In the elephants, only two kinds of teeth are represented, these be-

ing the incisors, or front teeth, and the molars, or grinders; while the front teeth themselves only exist in the upper jaw. The incisors grow from "permanent pulps," and hence they increase during the whole life of the animal, or nearly so. A large pair of tusks may weigh from one hundred and fifty to two hundred pounds, and as regards struct-

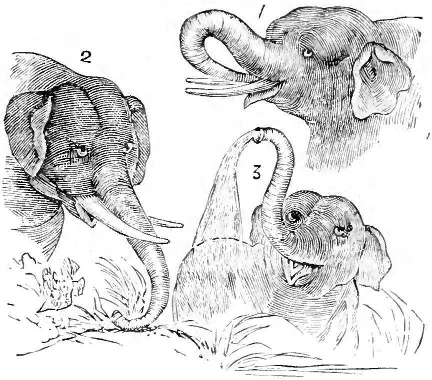


FIG. 2.—VARIOUS USES OF THE PROBOSCIS.

ure they are found to consist of dentine, or "ivory," and of "cement"; while the enamel, which forms such a characteristic feature of ordinary teeth, may or may not be represented. The tusks vary, according to Darwin, "in the different species or races according to sex, nearly as do the horns of ruminants. In India and Malacca, the males alone are provided with well-developed tusks. The elephant of Ceylon," adds Mr. Darwin, "is considered by most naturalists as a distinct race; there, 'not one in a hundred is found with tusks, the few that possess them being exclusively males.' The African elephant is undoubtedly distinct, and the female has large, well-developed tusks, though not so large as those of the male." The molars, or grinding-teeth, exhibit an equally curious structure. In the life-time of an elephant twenty-four molar teeth are developed in all, six on each side of each jaw. But, at any one time in the life of the animal, not more than two of these teeth are to be seen in each side of the jaw. A curious succession of these molars takes place in the elephants, for they are found to move from behind forward, the teeth in use being gradually ousted from their place by their successors as the former are worn away. Thus the whole set of molars in due time moves forward in the jaw and each successive tooth is, as a rule, larger than its predecessor. In structure, the molars of the elephant are highly peculiar, each exhibiting the appearance rather of a compound than of a single tooth. Each tooth is built up of a series of plates set perpendicularly in the tooth, and consisting of ivory, or "dentine," covered by enamel, while "cement" fills up the interspaces between the plates. As the tooth wears in its work, the enamel comes to project above the surface of the tooth,

and a characteristic pattern is thus developed on the surface of the molars of each species of living elephant. Thus, in the Indian elephant, the molars exhibit a series of cross-ridges, which are more numerous than those of the African species, while in the latter form the enamel plates form a distinctly lozenge-shaped pattern. It sometimes happens that in elephants kept in captivity the succession of the teeth is disarranged, from the fact that the molars are not worn away fast enough, and the succeeding teeth are displaced, thereby causing deformity of the jaws.

The elephants were included in the older systems of classification in a somewhat heterogeneous group of quadrupeds named the *Pachydermata.* That this order—now abolished and divided to form several new groups—was motley enough in its representation is readily seen, when we discover that the rhinoceroses, hippopotami, and other forms were included within its limits along with the elephants themselves. The technical name "Pachydermata" related to the thick skin which invests the bodies of the animals just mentioned, and in the elephants this characteristic is, of course, extremely well represented. The thick skin hangs in folds on the body, while the typical hair-covering which, by natural right, all quadrupeds possess, is but sparsely developed. It would seem, however, that the young elephant possesses a much more profuse covering of hairs than the adult. Such a statement is consistent with the general biological law which holds that the young form exhibits the primitive characters of the race more typically than the adult. In this view of matters the young elephant is nearer the type of its ancestors than the adult; and in the young whales the same remark holds good; since the youthful cetaceans may possess a sparse covering of hairs, such as the adults do not exhibit.

Speaking of the comparative hairlessness of the elephant and rhinoceros, Mr. Darwin remarks that, "as certain extinct species (e. g., mammoth) which formerly lived under an Arctic climate, were covered with hair, it would almost appear as if the existing species of both genera had lost their hairy covering from exposure to heat. This appears the more probable, as the elephants in India which live on elevated and cool districts are more hairy than those on the lowlands."

The social history and psychology of the elephant race form of themselves topics wide enough to fill a volume. From the earliest times, these animals have been enlisted by man in the service of war, or as beasts of burden, as aids in the chase, or even in the brutal and demoralizing sports of the ancient arena. The value of ivory in the earliest ages must have given rise to elephant-hunting as a source of gain and profit; and the inroads of man upon the species have naturally caused not merely a limitation in the numbers of these animals, but have likewise served to modify, in a very marked fashion, their geographical distribution. But the utility of these great animals to man depends as much upon their docility and tractable nature as

upon their manufacture of ivory. Probably there is no more sagacious animal than a well-trained elephant, and the development of such high instincts as these animals exhibit may form an additional illustration of the marked influence of association with man in inducing the growth of intelligence and reasoning powers in the animal creation. No one may doubt that the dog, for instance, has benefited to a marked degree from such association with human surroundings, and that the comparatively low mental powers of many other animals are susceptible of higher development through domestication is an idea fully supported by all that is known of instances where a wild race, or individual animal of wild habits, has been brought in contact with man. The "learned pigs" and tame hares are cases in point; and the relatively low mental powers of many of the apes may be largely attributed to that want of interest in "poor relations" with which humanity, as a body, views the quadrumanous tribes.

The records of popular natural history teem with examples of the sagacity of elephants, a mental quality which, it may be added, is likely to owe much to the relatively long life and corresponding opportunities of acquiring experience which these animals possess; while it has been also remarked that, as the elephant, unlike the dog, rarely breeds in captivity, and as each individual elephant has to acquire, independently of heredity, its own knowledge of the world and of man, so to speak, these great animals present infinitely more remarkable examples of animal sagacity than the dog. One specially interesting feature of elephant-life consists in the aid given by the domesticated elephant to man in the capture of the wild species. The fact of these animals entering into an offensive and, from its very nature, an intelligent alliance with man, against their own race, may be regarded either as illustrating the desire to benefit the race by conferring upon them the blessings of civilized life and employment, or as exemplifying a process of demoralization and treacherous development which might afford an argument against the universally beneficial effects of domestication of the animal form. Nor is the probem rendered any the less attractive to the metaphysician and moralist, when it is discovered that it is through the caresses and blandishments of the false females that the wild elephants are tempted into the snare: the parallelism between the experiences of lower and higher life being too obvious in this instance to escape remark.

Probably no animal exhibits a greater knowledge or instinctive apprehension of danger than an elephant. Instances are numerous, for example, when an elephant has refused to cross a bridge esteemed safe by his human guides, but which has collapsed with the animal's weight, when, goaded and tortured to proceed, he has advanced in despair, only to find himself immersed in the water below. But cases are also recorded in which the danger experienced by the elephant itself has apparently not rendered it insensible to the safety of its keeper. "The

elephant," says Darwin, "is very faithful to his driver or keeper, and probably considers him as the leader of the herd. Dr. Hooker informs me that an elephant which he was riding in India became so deeply bogged that he remained stuck fast until the next day, when he was extricated by men with ropes. Under such circumstances elephants will seize with their trunks any object, dead or alive, to place under their knees to prevent their sinking deeper in the mud; and the driver was dreadfully afraid lest the animal should have seized Dr. Hooker and crushed him to death. But the driver himself, as Dr. Hooker was assured, ran no risk. This forbearance, under an emergency so dreadful for a heavy animal, is a wonderful proof of noble fidelity." Swainson gives a description of the sagacity of an elephant under such circumstances which is worth quoting in the present instance: "The cylindrical form of an elephant's leg—which is nearly of equal thickness—causes the animal to sink very deep in heavy ground, especially in the muddy banks of small rivers. When thus situated, the animal will endeavor to lie on his side, so as to avoid sinking deeper, and, for this purpose, will avail himself of every means to obtain relief. The usual mode of extricating him is much the same as when he is pitted; that is, by supplying him liberally with straw, boughs, grass, etc.; these materials being thrown to the distressed animal, he forces them down with his trunk, till they are lodged under his fore-feet in sufficient quantity to resist his pressure. Having thus formed a sufficient basis for exertion, the sagacious animal next proceeds to thrust other bundles under his belly, and as far back under his flanks as he can reach; when such a basis is formed as may be, in his mind, proper to proceed upon, he throws his whole weight forward, and gets his hind-feet gradually upon the straw, etc. Being once confirmed on a solid footing, he will next place the succeeding bundles before him, pressing them well with his trunk, so as to form a causeway by which to reach the firm ground. . . . He will not bear any weight, definitely, until, by trial both with his trunk and the next foot that is to be planted, he has completely satisfied himself of the firmness of the ground he is to tread upon. . . . The anxiety of the animal when bemired forms a strong contrast with the pleasure he so strongly evinces on arriving at *terra firma*." Such an account becomes extremely interesting, as convincing us that much, if not all, of the sagacity which is called forth by such circumstances must be inherent and original, as opposed to that gained by experience. It can not be supposed that the accident described can form such a frequent experience of elephant-existence in a wild state as to constitute a certain basis for acquired knowledge of what to do in the exigency. On the contrary, it seems more reasonable to suppose that the inherent and intuitive sagacity of the animal is simply called forth by the threatened danger, and that such an exigency brings into play mental acts analogous to those whereby, through mechanical and similar contrivances to those employed by the

elephant, man might rescue himself or his property from immersion in the swamps.

The memory of elephants is of a highly remarkable nature, both as to its duration and in its operation as enabling the animal to recognize friends and foes. I am fortunate in being able to place on record an instance of elephant memory of a very interesting kind, and one which serves to show in a highly typical manner the remembrance by these animals of kindness, and also of the reverse treatment. In 1874 Wombwell's menagerie visited Tenbury, in Gloucestershire, and on that occasion the female elephant, "Lizzie" by name, drank a large quantity of cold water when heated after a long walk—the animal, as a consequence, being attacked with severe internal spasms. A local chemist, a Mr. Turley, being called in as medical adviser, succeeded in relieving the elephant's pain, the treatment including the application of a very large blister to the side. The menagerie in due course went its way; but, in May, 1879, it again visited Tenbury, and, as Mr. Turley stood at his shop-door watching the zoölogical procession pass down the street, the elephant stepped out of the ranks, crossed from one side of the street to the other, and, having advanced to Mr. Turley, placed her trunk round his hand and held it firmly, at the same time making, as Mr. Turley informs me, a peculiar grunting noise, as if by way of welcome. Thus it was clear that, after an interval of five years, "Lizzie" had recognized an old friend in Mr. Turley, and that, moreover, she remembered him with a sense of gratitude for his successful endeavors to relieve the pain from which she had suffered. At night Mr. Turley visited the menagerie, when the elephant again made every demonstration of joy, and embraced him with her trunk. She drew Mr. Turley's attention particularly to the side whereon the blister had been applied, thus showing that all the circumstances of five years previous were fresh in her memory. Observing that in 1881 the menagerie had again visited Tenbury, I wrote to Mr. Turley, inquiring if "Lizzie" had again recognized her old friend. That gentleman replied, his letter bearing date May, 1881, that she had again recognized him, beginning to "trumpet" whenever she beheld Mr. Turley among the spectators in the menagerie. On his speaking to his patient, she placed her trunk round his legs and lifted him from the ground, but in the gentlest manner possible. On Mr. Turley proceeding to examine one of her hind-legs, which had been under treatment, the elephant kept holding one of her fore-legs toward him in such a fashion as to draw his attention to the limb. As Mr. Turley, however, had had no concern with the fore-leg, he was puzzled to account for the animal's movement; but the keeper explained that the fore-leg in question had been treated by a veterinary surgeon for an injury, and that the latter had used his lancet to afford relief. The elephant was irritated by the operation, and expressed her resentment on again seeing the veterinary practitioner by striking at him with her trunk. The act of call-

ing Mr. Turley's attention to the fore-leg was simply an expression of admiration for the gentler treatment to which he had subjected his patient; the quieter medical treatment contrasting apparently with the rougher surgical measure to which the fore-leg had been subjected. It is thus clear not merely that the elephantine nature is endowed with an active memory, but that a lively sense of gratitude for past kindness is also represented in the list of mental attributes of this giant race.

A parallel instance of elephant memory is afforded by the case of an elephant which, having broken loose from the stables on a stormy night, escaped into the jungles. Four years thereafter, when a drove of wild elephants was captured in the "keddah," or inclosure, the keeper of the lost elephant went to inspect the new arrivals, and climbed on the railings of the "keddah" to obtain a satisfactory view of the captured animals. Having fancied that among the animals he recognized the escaped elephant—an idea ridiculed by his comrades—he called his lost charge by name. The animal at once came close to the barrier, and, on the keeper proceeding into the inclosure and commanding it to lie down, the elephant obeyed, and the man led his former charge triumphantly forth from among its wild companions. But the memory of kindnesses is equaled in the elephant by that which recalls acts of injury to remembrance. The well-known story of the Indian elephant which, on being pricked by a native tailor near whose stall it had wandered, returned and deluged the man with a shower-bath of dirty water, finds many parallels in the history of elephant character. An elephant, which was kept at Versailles by Louis XIV, was in the habit of revenging himself for affronts and injuries. A man who, feigning to throw something into his mouth, disappointed him, was beaten to the ground with the trunk and trampled upon. On a painter desiring to sketch this elephant with trunk erect and mouth open, his servant was instructed to feed the elephant for the purpose of inducing the animal to assume the desired attitude. But, the supply of food falling short and elephantine chagrin being aroused, the elephant, drawing up water into his trunk, coolly showered it down upon the unfortunate painter and his sketch, drenching the one, and rendering the other useless.

The pugnacity of the elephant is very great, and the determination with which contests are carried on between these animals is highly remarkable. Mr. Darwin, on the authority of the late Dr. Falconer, tells us that the Indian species fights in varied fashions, determined by the position and curvature of his tusks. "When they are directed forward and upward, he is able to fling a tiger to a great distance—it is said to even thirty feet; when they are short and turned downward, he endeavors suddenly to pin the tiger to the ground, and, in consequence, is dangerous to the rider, who is liable to be jerked off the howdah"—for it is on

"Elephants endorsed with towers,"

as Milton has it, that the great carnivore of India is hunted. A most remarkable trait of elephant existence, and one which parallels the proverbial "red rag" and bovine fury, is the apparent animosity of the race to white color. Sir Samuel Baker says that both the African elephant and the rhinoceros attack gray or white horses with fury. The explanation of such traits of character probably lies hidden in that philosophy of color in relation to sex and animal development which the reseaches of Darwin and others have so far unraveled.

As a final observation regarding the psychology of the elephant, Mr. Darwin's statements concerning the "weeping" of these animals may be quoted. Remarking that the Indian species is known to weep, Mr. Darwin quotes Sir Emerson Tennent, who says that some "lay motionless on the ground, with no other indication of suffering than the tears which suffused their eyes and flowed incessantly." Another elephant, "when overpowered and made fast," exhibited great grief; "his violence sank to utter prostration, and he lay on the ground, uttering choking cries, with tears trickling down his cheeks." "In the Zoölogical Gardens," says Darwin, "the keeper of the Indian elephants positively asserts that he has several times seen tears rolling down the face of the old female, when distressed by the removal of the young one." Mr. Darwin also makes the interesting observation that, when the Indian elephant "trumpets," the orbicular muscles of the eyes contract, while in the "trumpeting" of the African species these muscles do not act. Hence, as Mr. Darwin believes that in man the violent contraction of the muscles round the eyes is connected with the flow of tears, it would seem by analogy to be a legitimate inference that the Indian elephant has attained a higher stage in the expression of its emotions than its African neighbor.

The social history of the elephants includes several somewhat melancholy incidents connected with the dispatch of these animals, rendered necessary from their dangerous condition. The best known of these incidents is that connected with the death of Chunee, the Exeter Change elephant, reported in the "Times" for March 2, 1826. The account of the death of Chunee is as follows:

The elephant was a male, and had been an inmate of the Exeter Change Menagerie for seventeen years. He was brought from Bombay, where he was caught when quite young, and was supposed to be about five years old when purchased by Mr. Cross; consequently his present age is twenty-two. The effect of his unavoidable seclusion had displayed itself in strong symptoms of irritability during a certain season from the first, and these symptoms had been observed to become stronger during each succeeding year as it advanced toward maturity. The animal was altogether kept at this season very low, and also plentifully physicked, for which latter purpose no less than one hundred-weight of salts was frequently given to him at a time. Notwithstanding these precautions, the animal within the last few days had shown strong proofs of irritability, refusing the caress of his keepers and attempting to strike at them with his trunk on their approaching him, also at times rolling himself about his den and

forcibly battering its sides. About 1 P. M. he became more ungovernable than ever, and commenced battering the bars of his den with his trunk. These bars are upward of three feet in girth, and are composed of oak, strongly bound on all sides with iron, and are placed about a foot asunder. For some time they resisted the ponderous blows which he almost incessantly directed against them, but by 2 P. M. one of them was found to be started from the massive cross-beam into which it was mortised: and, as at that time the animal still continued as violent as ever, serious fear began to be entertained lest he should break out, in which event the amount of damage or loss of life which he might occasion would have been incalculable. In these circumstances, although the value of the animal was at least one thousand pounds, Mr. Cross at once determined on having him destroyed, and after some consideration it was resolved to give him some corrosive sublimate in a mess of hay. However, the animal no sooner smelled the mixture than he rejected it, and it was then determined to shoot him. Accordingly, a messenger was sent to Somerset House, where two soldiers were on guard, who, on a suitable representation being made, were allowed to go over to the menagerie, taking with them their muskets. Several rifle-guns were also obtained from different places in the neighborhood and put into the hands of such of the persons about the establishment as had courage enough to remain in the room. In this manner, in all about fourteen persons were armed, but before commencing operations it was deemed prudent to secure the front of the den, by passing cords around those bars against which the animal's violence had been principally directed. This having been done and the muskets loaded, about a third of the party advanced to the front of the den till within about five yards of the animal and discharged their pieces at the tender part of the neck below the ear, and then immediately retreated to a recess at the lower end of the room for the purpose of reloading. The animal, on finding himself wounded, uttered a loud and piercing groan, and advancing to the front of the den struck his trunk several times with all his fury against the bars, another of which he succeeded in forcing out of its place. Having thus exhausted his fury, he became quiet, upon which another detachment of the party approached his den, and, after firing upon him, retired into the recess as before; the animal on receiving the fire plunged again most violently against the front of the den, the door of which he actually lifted from off its uppermost hinges, but was prevented from getting out by the strong manner in which the ropes bound the different bars together. On his becoming more tranquil, preparations were made for firing a third volley; but no sooner were the muskets about to be leveled than the animal, as if conscious of their being the cause of his wounds and also of the vulnerable parts against which they were intended to be directed, turned sharp round and retreated into the back of the den and hid his head between his shoulders. It hence became necessary to rouse him by pricking him with spears, which being effected, the muskets were discharged at him, and, although several balls evidently took effect in the neck on this as well as on the former occasion, still he did not exhibit any signs of weakness, beyond abstaining from those violent efforts which he had previously made against the front of his den; indeed, from this time he kept almost entirely at the back of his den, and, although blood flowed profusely from the wounds he had received, he gave no other symptoms of passion or pain than an occasional groan. For about an hour and a half in this manner a continuous discharge of musketry was kept up against him, and no less than one hundred and fifty-two bullets were expended before he fell to the ground, where he lay nearly motionless, and was soon de-

spatched with a sword, which, after being secured upon the end of a rifle, was plunged into his neck. The quantity of blood that flowed was very considerable, and flooded the den to a great depth. This was the same elephant who was the *accidental* cause of its keeper's death, whose ribs it crushed four months back while in the act of turning round in its den.

After reading this account, we may well feel tempted to indorse the opinion of a correspondent of "Land and Water," who remarks that the like of it "can never occur again, thank God, in England!"

The history of the elephants would be manifestly imperfect, even when detailed in the briefest manner, without a reference to their present distribution and to the biography of the race in the past. As in the case of many other groups of animals and plants, we can only fully appreciate the modern relations of the elephants when some knowledge of their development in the geological ages has been obtained. In the eyes of the modern naturalist, the present of any living being is not merely bound up in its past development, but the existing conditions of any race become explicable in many cases only when the former range of the group in time has been ascertained. This holds especially true of the elephants; for the existing species represent the remnants of a once larger and far more extensive distribution of proboscidian life. Hence, it behooves us to make the acquaintance, firstly, of their present distribution, and secondly of their distribution and development in past ages, if we are to understand with any degree of completeness and mental satisfaction the relations of the elephantine races.

The distribution of the elephant on the earth as it now exists may be disposed of in a very few words. The Indian species occurs in Asia, from the Himalayas to Ceylon, while its range extends eastward to the Chinese borders, and southward to Sumatra and Borneo as well. The African species possesses as localized a habitat. It was Swift who, remarking on the customs of geographers in his day, said:

> "So geographers in Afric maps
> With savage pictures fill their gaps,
> And o'er unhabitable downs
> Place elephants for want of towns."

The witty dean's lines show at least that the geographers did not mistake the wide distribution of the giant animal in the Ethiopian continent. For, south of the Sahara—the territory north of which is zoölogically a part of Europe—the African elephant is everywhere found, forming one of the most characteristic features at once of the African landscape and of the Ethiopian fauna, and dividing the sovereignty of the land with the lion himself.

Turning now to the past history of the elephant race, one may primarily note the more prominent members of the group which rank among the curiosities of the geologist. First in order comes the extinct mammoth—the *Elephas primigenius* (Fig. 3) of the naturalist.

Of this huge elephant we possess considerable knowledge, inasmuch as specimens have been obtained, literally packed amid the Siberian ice, and so perfectly preserved that even the delicate tissues of the eyes could be inspected. This was the case in the famous specimen found in the frozen soil of a cliff at the mouth of the Lena in 1799. The skin of this huge elephant was then seen to be clothed with a thick coating of reddish wool interspersed with black hairs. The skeleton, removed in 1806 by Mr. Adams, and preserved in St. Petersburg, measures sixteen feet four inches in length, the height is nine feet four

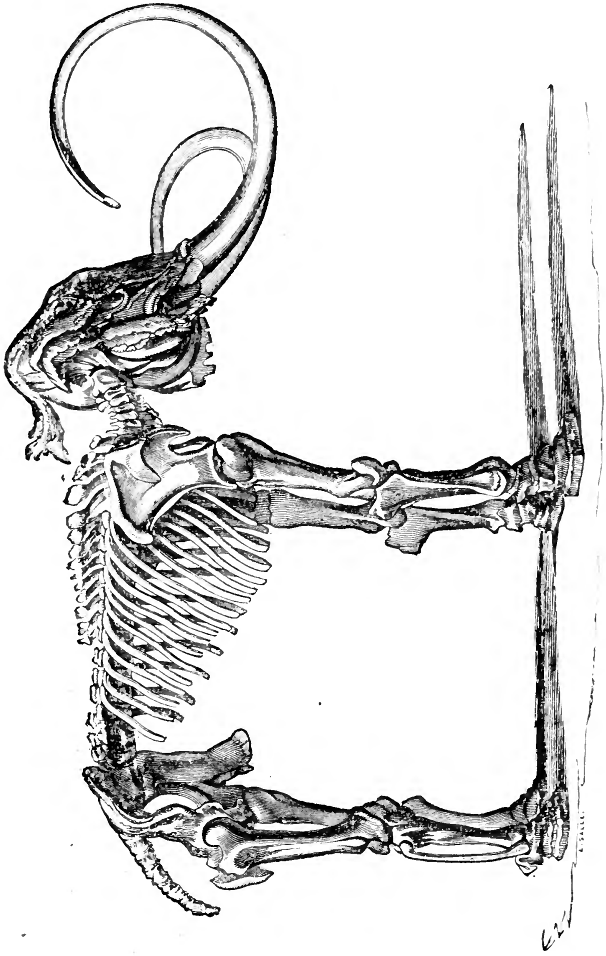


FIG. 3.—SKELETON OF MAMMOTH.

inches, and the tusks measure each nine feet six inches along their curve. The mammoth's tusks appear to have had a wider curvature (Fig. 3) than those of existing elephants ; and probably, like the African species, both male and female mammoths possessed these great teeth. The measurement of mammoth tusks from recent deposits in

Essex gives a length of nine feet ten inches along the outer curve, and two feet five inches in circumference at the thickest part. Another specimen weighed one hundred and sixty pounds; and a dredged specimen taken off Dungeness was eleven feet long. The mammoth's tusks have long formed articles of commerce and barter in Siberia; the ivory, as Professor Owen remarks, being "so little altered as to be fit for the purposes of manufacture." The mammoth's extensive range forms not the least noteworthy point in its history. It certainly roamed farther abroad, so far as we know, than any other elephantine form. Its remains occur in Britain and in Europe generally; they have been found on the Mediterranean coast and in Siberia; and they are met with in North America as well. In Scotland and in Ireland the mammoth was apparently less plentiful, but its remains occur in these countries, where, indeed, no other elephantine remains are found. It may be added that the molar teeth of the mammoth are by no means unlike those of the Indian elephant in the arrangement and pattern of its enamel plates.

Another extinct elephant, equally famous with the mammoth, was the *Mastodon*—a name given to these animals in allusion to the nipple-like projections seen on the surface of the molar teeth. Their remains occur in Europe, Asia, and in North and South America. In the morasses of Ohio and Kentucky, for example, whole skeletons of these interesting elephants have been discovered. The length of the mastodon in some cases exceeded sixteen feet; and the tusks have been found to measure twelve feet in length. Over a dozen species of mastodons have been described, but they agree in certain important characters which serve to distinguish them from other elephants. Thus, the roughened teeth appear to have been adapted for bruising coarse herbs and leaves—indeed, associated with mastodon remains in America collections of leaves have been found occupying the situation in which the stomach of the animal would have been situated, and thus indicating the dietary of these extinct giants. Furthermore, a most important difference between the mastodons and other elephants is found in the fact that these animals possessed two tusks springing from the lower jaw, in addition to the tusks with which, as in ordinary elephants, the upper jaw was provided. But it would seem that these lower tusks never attained a large size, while it is probable that they fell out when the animal attained the adult period of its existence.

More extraordinary still, in respect of its variations from the ordinary structure of the elephants, was the *Dinotherium* (Fig. 4), the fossil remains of which occur in Europe and in India. The skull of a dinotherium has been found to measure four feet in length, while a thigh-bone was five feet three inches long. Thus, in so far as size is concerned, the dinotherium may claim a foremost place among its elephantine cousins. But various circumstances seem to suggest that the latter animal departed from the elephant type in certain important

particulars, while some authorities have been even found to suggest that it represents a connecting link between the elephants and the sea-cow or manatee order (*Sirenia*). The tusks of dinotherium spring from the lower jaw (Fig. 4) ; and instead of being curved forward and upward, they bend abruptly downward and backward. The use of these tusks is extremely difficult to determine, but it has been suggested that the dinotherium was an aquatic animal, living in shallow waters, and that these huge teeth may have enabled it to root up the plants on which it fed, or have enabled it to climb, as does the living walrus, from the sea on to the river-banks.

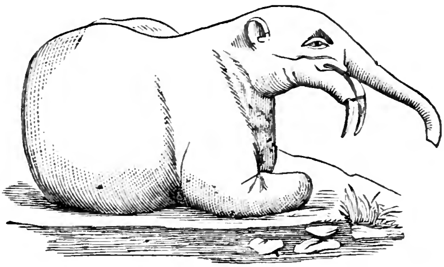


FIG. 4.—RESTORATION OF DINOTHERIUM.

In addition to these latter elephants, which are essentially distinct from the living species, certain extinct forms may be mentioned which, in their essential characteristics, resembled existing proboscidians more or less closely. Thus, we know that elephants closely related to the Indian species existed in Asia in Miocene times, the remains of at least six species being obtained from Indian deposits of that age ; and we also know that Europe boasted of elephants in that period of geology known as the "Pliocene" ; for in the deposits of France and Italy, as well as in the formations of that age in Britain, elephant remains occur. Later in point of time come the curious "pygmy elephants" of Malta, whose remains exist in that island, and whereof one (*Elephas Melitensis*) attained the size of a donkey, while another (*Elephas Falconeri*) was smaller still, and averaged two and a half or three feet in height.

The geological order and the succession in time of these various elephants is important to trace ; for the unraveling of so much of the past history of the elephants as is known to us depends upon the knowledge of their succession and of the periods of their appearance and extinction. If we tabulate the rocks wherewith the past of the elephants is concerned, we may render their arrangement clear thus :

TERTIARY ROCKS, including	QUATERNARY,	Recent (Soils, etc.). Post-Pliocene (Ice Age).
	PLIOCENE,	
	MIOCENE,	
	EOCENE,	

Thus the oldest and lowest of the Tertiary rocks—which are themselves collectively the most recently formed—is the "Eocene," and the succeeding "Miocene," "Pliocene," and "Quaternary," are given in their due order; the latter formations bringing us to the soils and surface accumulations of our own day. The "Ice Age," or "Glacial Epoch," we may also note, occurred during the Post-Pliocene period, as shown above.

Turning now to the past history of the elephants, we find the first chapter of that biography to open in the "Miocene" age. The earlier or "Eocene" period contains no elephant fossils, and it may have been that in this Eocene age, which beheld the first beginnings of nearly all the existing quadruped races, the evolution of the elephant stock from its ancestry was taking place. Leaving for the present the consideration of the probable root of the elephantine tree, we thus discover in the Miocene period the first beginnings of elephant existence. In this period the mastodons roamed over Europe and India, while in this age also the dinotheriums, with their great lower tusks, made their first appearance on the stage of time. As the geological series progressed, and as the Pliocene age succeeded the Miocene times, we discover the elephants in increasing numbers. The Miocene, with its relatively few elephantine forms, contrasts forcibly with the increase of those animals in the succeeding age. Europe and India harbor its Pliocene elephants, as we have seen; while both Europe and America in this latter age possessed the mastodons. The Post-Pliocene period, however, dawns in turn, to find the mastodons still existent in North America, but unknown in Europe; while the mammoth now appears as a representative form, along with survivals of the European elephants of the Pliocene time. The "pygmy elephants" of Malta also belong to the Post-Pliocene age.

Thus we discover that a distinct *succession of types* of elephantine forms has taken place on the earth's surface, beginning with elephants which, like the dinotherium and mastodon, differ from existent species, and ending with elephants which, like the mammoth or the European elephants of the Pliocene, more or less closely resembled the quadruped giants of to-day. It becomes interesting further to trace out the later history of the race before the bearings of these facts on the origin of the elephant race are discussed. The mammoth, for example, certainly survived the "ice-age," to the irruption of which was probably due the extinction of the other elephantine forms. We know of this survival because its remains occur in "recent" or "post-glacial" deposits. We are also certain that early man must have beheld the mammoth as a living, breathing reality, for its remains have been found associated with the rude implements of early men, and a rough portrait of the great red-haired elephant has been discovered, scratched on one of its tusks—a rude but unquestionable tribute of early art to the science of zoölogy. Its woolly hair, protecting it against

the rigors of the ice-age, may have enabled it to survive that period, which was apparently so fatal to elephant life at large.

Summing up the details we have thus collated, from the geological side, we may now face the problem of the origin of the elephant race. Not that the problem itself is fully answerable, for our knowledge of the elephant race in the past is yet of comparatively limited extent; but the main lines of the biological argument are clear enough to those who will consider, even casually, the evidence already at hand. It is thus clear that the true elephants, which belong to the Pliocene period, are ushered into existence, so to speak, by forms that are less typical elephants—mastodon and dinotherium—when judged by the standard of existent elephantine structure. There are various species of mastodons known to geologists, which exhibit a gradation in the matter of their teeth, and presumably in other structural aspects as well, toward the ordinary elephant type. As the mastodons precede the ordinary elephants in time, we shall not be deducing an unwarrantable inference if we maintain that the origin of the true elephants, both fossil and living forms, may safely be regarded as arising from the mastodon stock. The elephants of to-day are connected by links of obvious nature with the Pliocene and Post-Pliocene forms; and, when the "ice-age" cleared the earth of the vast majority of the species, the progenitors of our living elephants must have escaped destruction and have survived the cold, possibly in the regions wherein they now exist, just as the mammoth, in its turn, survived the rigors of the ice-period, through the presence of its woolly coating and its hardier constitution. There seems thus to be no special difficulty, either of purely geological or of intellectual nature, in conceiving that the elephants of to-day are simply survivals of that elephantine host, whose existence was well-nigh terminated by the "ice-age," and which left the mammoth, and the progenitors of our living elephants, to replenish the earth after a catastrophe as sweeping and fatal in its nature as any deluge.

But if the origin of the modern and later elephants may thus be accounted for, and if their geographical birthplace may be assumed to exist within the confines of the Old World, a more fundamental and anterior query may be put with reference to the origin of the mastodon stock, which we have supposed, and with reason, is the founder of the true elephant races. From what stock, in other words, did the mastodons themselves arise? The chain of organic causation, to be perfect and complete, can not assume the mysterious origin of the mastodon. That stock must, in its turn, have originated in an ancestry less like the elephants than itself. It is not improbable that the evolutionist of the future will seek and find the mastodon ancestry in the dinotherium group, or in some nearly related forms. For, as we have seen, the dinotherium exhibits a structure which appears to relate the elephants to other and lower quadrupeds, such as the sea-cows

and their neighbors. If this supposition be permissible, then a further stage still awaits our intellectual journey in the search after the origin of the elephant races. In the Eocene rocks of North America occur the fossil remains of some extinct quadrupeds, of which the *Dinoceras* is the best-known form. These animals unite in a singular fashion the characters of elephants and ordinary "hoofed" quadrupeds. While they possessed horns, they also developed tusks from the eye-teeth; and, from a survey of their complete organization, Professor Marsh tells us that the position of these unique quadrupeds is intermediate between the elephants themselves and the great order to which the hoofed quadrupeds belong. Dinoceras and its neighbors precede the dinotherium and mastodon in time, and this fact alone is important as bearing on the assumed relationship of these forms.

It may thus at present be assumed with safety that the evolution of the elephants has taken place from some ancient Eocene quadruped stock, represented by the Dinoceras group, which belongs to no one group of living quadrupeds, but is intermediate in its nature, as we have already observed. From some such stock, then, we may figure the dinotherium and mastodon races to have been in due time evolved. The New World, in this light, must have been the birthplace of the elephant hosts; for the Dinoceras and its neighbors are of North American origin; migration to the Old World having taken place by continuous land-surface then existent, and the further evolution of the living species and their fossil neighbors having occurred in the Eastern hemisphere. Thus, once again we arrive at the existing races of elephants. These are simply the survivals of an ancient line of quadrupeds, whose history is simply that of every other living being—animal or plant—a history which, like the unfolding of a flower, leads us from form to form, along pathways of variation and change, and which, at last, as the ages are born and die, evolves, from the buried and forgotten races of past monsters, the no less curious and unwieldy quadruped giants of to-day.—*Belgravia.*

THE CHEMISTRY OF SUGAR.

By Professor HARVEY W. WILEY.

THE annual consumption of sugar by the people of the United States amounts to more than forty pounds *per capitum*. This gives as a total the enormous quantity of two billion pounds per annum. The cost of this commodity may be safely placed at eight cents a pound. The total value of the sugar consumed each year, therefore, is one hundred and sixty million dollars. Sugar is a theme of general and pecuniary interest, which is a sufficient excuse for an article on its chemistry.

Sugar is a general name applied to a class of bodies composed of carbon, oxygen, and hydrogen, having a more or less sweet taste, and exercising a rotatory power on the plane of polarized light.

In chemical composition the sugars may be regarded as a combination of water with carbon, and they belong therefore to that class of bodies which are known as carbo-hydrates. Starch, wood-fiber, and various sorts of gums are bodies nearly allied in chemical composition to sugar.

Sugar is chiefly a product of vegetable growth, and is found in some part or other of a large number of substances.

Sometimes it is found in the root, as in the beet and sweet-potato. Again, it occurs in the fruit, as in the grape and water-melon. At other times it is stored in the juices of the plant, as in the maple-tree and the sugar-cane.

In whatever position it occurs, it is always diluted with water, and mixed with various gums and albuminous bodies peculiar to the plant containing it.

The manufacture and refining of sugar consist in separating it from these impurities, and evaporating the water until the crystallizing point is reached, or a sirup is produced.

I have said that sugar is of vegetable origin. This must be construed to mean the sugars of commerce and common consumption. The animal organism possesses a glycogenic function in common with plants.

The amount of sugar, however, produced by the animal organism, with the exception of that from the milk-glands, is inconsiderable in a state of health. In certain forms of disease, however, as in *diabetes mellitus*, the amount of sugar produced in the body may be immensely increased.

Sugar may also be made by chemical means from the bodies already mentioned, such as starch, cellulose, gum, etc.

In this sketch I will mention only the more important sugars. For the purposes of a popular classification the sugars may be arranged as follows:

1. Cane-sugar, or sucrose.
2. Grape-sugar, or glucose.
3. Milk-sugar, or lactose.
4. Starch-sugar, or amylose.

Cane-sugar, in a commercial sense, is by far the most important of these bodies.

It has never been formed by chemical synthesis, and the chief sources from which it is derived are the sugar-cane, the sugar-beet, and the sugar-maple. When pure it is a white crystalline body easily soluble in water and having an intensely sweet taste. The molecule of cane-sugar consists of forty-five atoms, distributed as follows, viz., twelve atoms of carbon, twenty-two of hydrogen, and eleven of oxy-

gen. By the hundred this is equal to 42·11 per cent of carbon; 51·46 per cent oxygen, and 6·43 per cent hydrogen. Its expression by symbols is $C_{12}H_{22}O_{11}$. The amounts of carbon and hydrogen in cane-sugar are determined by igniting it with oxide of copper or other substance rich in oxygen. By this process the carbon is converted into carbon dioxide (carbonic acid), and the hydrogen into water, each of which substances is easily collected and weighed.

Indeed, this process is used for estimating carbon and hydrogen in all sugars. The oxygen is usually estimated by difference.

It has thus been shown that oxygen and hydrogen exist in sugar in the exact proportions necessary to form water. A *materialistic* definition of sugar would be forty parts of fine charcoal mixed with fifty-eight parts of pure water. Yet charcoal and water mixed in the above proportions are far from being sweet; a good illustration of the difference between chemical union and mechanical mixture. Pure cane-sugar, when left to itself, has no tendency to change. When diluted with water, however, and brought in contact with a nitrogenous body it undergoes fermentation, and yields at first alcohol, carbonic dioxide, and other products, as will be shown subsequently.

Pure cane-sugar has the power of twisting the plane of polarized light to the right. For the purple ray or transition tint this torsion amounts to 73·8°, and for the monochromatic sodium-flame to 66·67°. These numbers represent its *specific rotatory power*.

I will give an explanation of what these terms and numbers signify further on. From this property the chemist is able to determine the amount of pure sugar in any sample submitted to him for examination, and containing no other optically active body. For, if, using the sodium-flame, he should find the rotation to be 33·34°, he would know at once that the sample contained only fifty per cent of sugar, and so on for other numbers. When cane-sugar is heated with an acid, or for a long time to a high temperature without one, it suffers a peculiar change which is called *inversion*. Inverted sugar has almost lost its power of crystallization, and has changed its deportment toward polarized light. It consists now of two distinct kinds of sugar, one of which turns the plane of polarized light to the left and is called *lævulose*, while the other turns it to the right and is called *dextrose*.

At ordinary temperatures, however, the lævo-rotatory power of inverted sugar is much greater than the other. This preponderance of lævo-rotatory power increases as the temperature falls, and diminishes as it rises. At 88° Cent., these two powers are equal, and the sugar exerts no influence whatever on polarized light.

These twin constituents of inverted sugar can be separated with lime, which forms with the lævulose a compound less soluble than with the dextrose, and from which the latter is separated by pressure. The lime compound is then decomposed by oxalic acid and the lævulose set free.

Honey is composed of left-handed or invert-sugar, some grape-sugar, and more or less cane-sugar. After keeping for some time the cane-sugar is all converted into the invert variety. When cane-sugar is heated to a temperature of about 200° C., it undergoes a transformation, and a part of it is changed into an aromatic substance called *caramel.* This change consists essentially in the loss of two molecules of water. Caramel is used chiefly in the manufacture of candies, for flavoring whiskies, brandies, etc.

A pleasing and instructive experiment which any one can try will show that sugar is made of charcoal and water. A strong solution of sugar is placed in a glass until the bottom is well covered. Strong sulphuric acid (oil of vitriol) is now added, and the whole stirred with a glass rod until it swells up and turns black. The sulphuric acid has a very strong liking for water, which it steals from the sugar molecules, leaving only the carbon.

Another interesting experiment is to burn the carbon in sugar with the oxygen in the chlorate of potassium, the fire being kindled with a drop of sulphuric acid. For this experiment four parts of sugar are carefully mixed in an old saucer with five parts of chlorate of potassium, and the mass then touched with a glass rod which has been dipped into strong sulphuric acid. The chemical action produced by the sulphuric acid makes heat enough to ignite the whole mass, and the carbon of the sugar is thus burned out.

Grape-sugar, as its name implies, is found in grapes and some other substances. This name is also sometimes incorrectly given to one, and often all the sugars made from starch or derived from fruits. It is dextro-gyratory, having for the sodium ray a specific rotatory power of about 52·5°. It is fermentable, and is not changed by heating with dilute acids. It crystallizes, but with less facility than cane-sugar, and is much less sweet to the taste. There are other varieties of sugar which possess the same properties as grape-sugar. To these the general name, *dextrose* or *glucose*, has been given. Any sugar, whatever be its source, which, in a dry state, has the formula $C_6H_{12}O_6$, and a specific rotatory power of 52·5° to the right, is entitled to the name *dextrose.*

Dextrose is also the final product of long-continued boiling of starch with an acid.

Starch-sugar, or amylose, is a mixture of various products, chief among which are dextrose, dextrine, and maltose.

For a full discussion of this sugar I refer to my paper in this magazine for June, 1881.

Milk-sugar, or lactose, is found in milk, and is not important commercially. It is used mostly as a vehicle for administering medicines. In composition it is identical with cane-sugar, but differs from it greatly in both chemical and physical properties.

Optically it is nearly related to dextrose, its specific rotatory power

being only a little greater. It is much less soluble and much less sweet than cane-sugar.

Both lactose and dextrose, where freshly dissolved from the crystalline state, have a rotatory power nearly double the normal. This peculiarity is called "birotation." Milk-sugar ferments when mixed with yeast, but not so readily as grape-sugar or dextrose. The fermented milk forms a mild alcoholic beverage much prized in some countries.

Most sugars readily combine with lime, and with the alkalies, and also with many of the ordinary salts. Cane-sugar especially combines easily with bases almost like an acid, forming salts which are called *sucrates.*

Many metallic compounds help the crystallization of the sugars, and such salts have been used in the refining of sugar for this purpose. Owing to the difficulty, however, of removing these compounds completely, the practice has been generally abandoned.

The action of sugars on copper compounds is of especial interest, because it is used as a means of estimating the quantity of sugar present in a substance.

Alkaline copper solutions, when heated with most sugars, have their copper reduced to the form of a suboxide (Cn_2O). Of the sugars which act in this way, I may mention grape-sugar, lactose, dextrose, and maltose. Pure cane-sugar does not act upon copper solutions until after it has been converted into invert-sugar. Dextrine or starch gum is likewise inactive. The copper solution generally employed for the estimation of sugar contains the copper in the form of a tartrate, with some sulphate of sodium and an excess of sodium hydrate in the mixture. It is called "Fehling's solution."

The specific rotatory power of a sugar is its property of twisting the plane of polarized light either to the right or left. The instrument used to determine this is called a polariscope, or saccharimeter. The instrument in more common use has an ordinary oil or gas lamp as the source of light. By quartz plates this light is modified in character so as to produce a tint most sensible to change. This is called the *transition tint,* or *teinte de passage.* It is a purplish color, which on the one side changes to blue, and on the other to a rose-red. In the last few years instruments using a monochromatic light are coming into use, and they have some advantages over the other kind. The one-color light is produced by passing the rays from a sodium-flame through a crystal of bichromate of potassium, by which a pure yellow is obtained.

The field of view in these instruments has only half its area filled by a quartz plate. When the instrument is adjusted to zero the quartz semi-disk offers no opposition to the passage of the light. Interposing, however, a tube containing a sugar solution, one half the field is darkened. The analyzer is then turned until the field is equally illuminated

again, and the angle through which it has been moved is read on a divided circle and vernier.

Since the rotation is less for the sodium-ray than for the transition tint, the two are distinguished by different symbols. For the former the symbol $[a]_D$ is used, and for the latter $[a]$ or $[a]_j$. The one-color saccharimeter is especially to be recommended for those who may be subject to any degree of color-blindness. A discussion of the optical principles involved in circular polarization would be out of place here.

Fermentation is a peculiar decomposition which sugars suffer under the influence of a nitrogeneous germ called the "ferment."

Cane-sugar, under the influence of a mucous sporule, undergoes "mucous fermentation," and is converted into a gum and a kind of sugar called "mannite." Neither acid nor alcohol is produced by this process.

Lactic fermentation takes place under the influence of an organism called *penicilium glaucum.* The chief product of this fermentative is *lactic acid.* In the case of a dextrose it may be represented by the following equation :

$$\underset{\text{Dextrose.}}{C_6H_{12}O_6} = \underset{\text{Lactic Acid.}}{2\,C_3H_6O_3}.$$

Milk-sugar undergoes this fermentation most readily, first absorbing a molecule of water and then breaking up into four molecules of lactic acid. If the process is allowed to go on, the lactic acid will break up into butyric acid, carbonic dioxide, and hydrogen. If the *Torula aceti* take the place of the germ named above, cane-sugar especially will yield acetic instead of lactic acid.

The *vinous* is by far the most important of the fermentations to which sugars are subjected.

Ordinary *yeast* is the nitrogenous body which seems best suited to develop this change.

Cane-sugar, before undergoing vinous fermentation, absorbs a molecule of water and is changed by an active principle of the yeast into invert-sugar. The chief products of vinous fermentation are alcohol and carbonic dioxide. Less important products are succinic acid, glycerine, cellulose, and fat.

All the sugar, with the exception of about four per cent., is converted into the two products first named. By an equation, the process may be represented as follows :

$$\underset{\text{Sucrose.}}{C_{12}H_{22}O_{11}} + \underset{\text{Water.}}{H_2O} = \underset{\text{Alcohol.}}{4\,C_2H_6O} + \underset{\text{Carbonic dioxide.}}{4\,CO_2}.$$

The peculiar fungus which is most active in the vinous fermentation is *saccharomyces cerevisiæ ;* but there is much about the process which is yet obscure.

In the conversion of starch into sugar by diastase or acids, and the conversion of sugar into alcohol by fermentation, we have the *rationale* of that vast industry carried on by distillers and brewers. If the

process of vinous fermentation is continued, the alcohol is converted chiefly into acetic acid (vinegar).

Decolorization.—Even a brief account of the chemistry of sugar would not be complete without an allusion to the methods employed to remove the coloring-matters naturally present in all sugars.

Sulphurous acid is sometimes employed for bleaching, but the carbon obtained by heating blood, bones, and other animal substances in closed retorts is by far the most efficacious means of decolorizing known. The pure white sugars and light-colored sirups of commerce are decolorized with this animal char. We may say that this decolorization is effected by oxidation of the coloring-matter, and yet the phenomenon does not appear to be wholly one of oxidation. Like the process of fermentation, it is difficult to explain it in full.

The solutions of sugar of a proper degree of dilution are passed, often under pressure, through successive filters of animal charcoal until their color is fully discharged.

Since a high temperature tends both to render sugar of a deeper color, and if it be sucrose to invert it, the evaporation of the sirup is carried on in vacuum-pans, whereby it is effected much more rapidly and without impairing the power of crystallization in the finished product.

From the multitude of facts connected with the chemistry of sugar I have endeavored to select those which are most important and of most interest to the general reader. Every intelligent man can not be a specialist in every department of science, but he can easily acquire a general idea of the progress of science. It is certainly a part of a liberal education to know something of the chemistry of common things.

This country ought to make its own sugar. The sugar-fields of Louisiana, with wiser management and a more scientific agriculture, could be made to increase their yield tenfold. Along the more northern parts of the Union the climate and soil are well adapted to the culture of the sugar-beet. We should not be discouraged because a few attempts in this direction have not proved financially successful. Twenty-five years of failure in Europe have been followed by fifty years of success, until at the present time two fifths of all the cane-sugar produced in the world are obtained from the sugar-beet. Last of all, the great Indian-corn-producing area of the country is peculiarly suited to the growth of the sorghum sugar-cane, and the production of crystallized sugar from this source is no longer a mere possibility. It has already been realized. Land which will produce forty bushels of corn per acre will yield from six hundred to a thousand pounds of sugar, and nearly one hundred gallons of sirup. In another decade, instead of having to import eleven twelfths of the sugar we consume, as we do now, we may hope to produce it all.

TRANSCENDENTAL GEOMETRY.

By ALFRED C. LANE.

TRANSCENDENTAL geometry is the geometry of solids and surfaces in n-dimensional or in curved space. Exactly what surfaces and what solids is a hard question to answer, and the answer is still harder to understand. Let us, then, first find out in what way or ways the science of transcendental geometry arose.

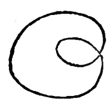
Descartes invented a method of applying algebra to geometry by the well-known Cartesian co-ordinates. As you remember, a point in a plane is determined by two co-ordinates, x and y, for example; a point in space by three, x, y, and z. Now, the question is not unnatural, "What would x, y, z, v, determine?" The natural answer is, "A point in space of four dimensions."

Moreover, we see that, although we have no experience of space of four dimensions, we could form equations between four variables, and transform and combine them as we do in analytic geometry of three dimensions. By adopting a code of interpretation as like to our ordinary code as circumstances would permit, we could interpret the relations of our equations as geometrical relations.

But, as the idea of a fourth dimension to space is almost if not quite inconceivable, let us endeavor to render it less so if possible. Imagine a man deprived of everything but vision, in the way of sensible experience. The world to him would be two dimensional. If, then, he were taken out to drive, he would see continual changes in his plane of vision, but he would ascribe them merely to the effects of *time.* For example, were he to go through a covered bridge, his sensations might be as follows: A small dark spot, gradually enlarging till it covers the field of vision; then a small bright spot in the middle of it, which would similarly enlarge.

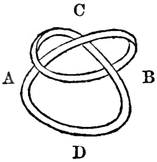
Now, suppose our universe sliced in two by a plane which moved along through it. Suppose sentient beings inhabited this plane. They would perceive at once two dimensions of our universe and the third as a *succession in time.* So we might suppose ourselves conscious of three dimensions of our universe, and of the fourth as the succession of things in time. Thus we might consider time as a dimension. It is so considered in the mechanical curves of position. Yet we should then have to bring in time relative to time.

We will illustrate still further by considering the theory of knots. It is evident that, so long as the line represented in the adjoined figure is kept in the plane, the knot or kink can not be got out of it. But, by turning the loop up, it can be removed at once.



The annexed knot—the type of all knots in ordinary space—can

not be undone without severing the ends. In four-dimensional space it could. By this means Zöllner interpreted some of the knot-untying performances of Slade, the American spiritualist. Let us, for example, interpret these facts, using time as fourth dimension, bringing in, of course, time relative to time. If time were a fourth dimension, parts of the state of things at different instants might be visible together. Thus we could have A, C, B, after being tied, joined to A, D, B, and then A, C, B, before being tied.



But we must remember, in passing on, that algebraic equations are capable of other than geometrical interpretations, and that their relations by themselves prove nothing in regard to real or possible relations between external facts. Moreover, the algebraic theory of dimensionality will be interpreted fully by nothing less than a space of infinite dimensionality.

We come now to the most difficult branch of the subject, that of curved surfaces and of curved space. The curvature of a plane curve at any point is the limit of the ratio of the length of the curve to the difference in direction of the initial and terminal tangents. Its differential expression is $D_t s$ or $\frac{D \times {}^2 y}{[1 + (D \times y)^2]^{\frac{3}{2}}}$. To get the curvature of a curved surface at any point, we slice it up by planes normal to it at that point. On each of these planes it will describe a curve. These curves will have different curvatures at the original point. The reciprocal of the product of the greatest and least of these is called by Gauss the measure of curvature. This name he also applied to an analogous function of the co-ordinates of a point in space. The expression, for a plane curve, of the curvature is the reciprocal of the radius of the circle of closest possible contact at the point investigated. Hence, some have argued that transcendental geometry was inconsistent, in that it talked about the curvature of a space where there were not Euclidean straight lines, hence no radii, and nothing to refer the curvature to. This argument is open to other answers, but it is enough to say that the measure of curvature has no necessary connection with radii.

To return, the condition that a rigid figure can be moved about on a surface without changing its shape, or that a rigid body can be similarly moved in space, is that the measure of curvature of the surface or space is constant in value. Some one might say that, if a body is rigid, no motion can change its shape. This, however, is not true of the mathematically rigid body except under the above conditions, taking the most general definition of a rigid body.

It is assumed in Euclid that motion of a figure does not alter it. That is, if an angle, A B C, is equal to an angle B C D, it will be equal to it however it is as a whole moved or rotated. This is an assumption that the measure of curvature of the plane or space is constant. Moreover, if we assume it constantly equal to naught, the

so-called geometrical axioms that two straight lines can not inclose a surface, etc., are true. For example, a spherical surface has a constant measure of curvature not equal to zero, and positive. Since the shortest distance between two points is a straight line, let us, extending the analogy, call the shortest distance between two points of a spherical surface, *lying wholly* in that surface, a straight line of that surface. Now, as the measure of curvature of a spherical surface is constant, we can slide a figure about over the surface without altering it, as is evident at once. On a sphere, however, more than one perpendicular can be drawn on the surface from a point to a straight line, and two straight lines can inclose a surface.

In a surface whose curvature is negative, an infinite number of straight lines of the surface can be drawn through a given point which will never meet a given straight line. Such a surface would be like a spool. Some of its sections would be concave and others convex to the same point. We have analogous results in what is called curved space. These results were first suggested by Riemann, who was a pupil of Gauss.

For this mathematical treatment all that is needed is, first, algebra and the differential calculus; secondly, a method of interpreting them geometrically. We have found a code of interpretation for some algebraic equations which give geometrical results, and we apply it so far as we can to all.

So far the mathematicians might have gone without let or hindrance, and there some of them, as Boole and Grassman, stopped. But others thought they had settled whether the geometrical axioms were *a priori* truths or not. We have just worked out a system of geometry, said they, which is not, as we think, impossible, where these axioms do not hold. Therefore these axioms are the results of an experience of things as they are. If we had had a different order of things, as is possible, these axioms would not have been true nor thought of. I shall, however, try to prove that, although not thought of, they are true.

The geometrical axioms express relations; relations between what?

Geometry is a branch of mathematics. Therefore the geometrical axioms express mathematical relations. What, then, is mathematics, and with what does it deal?

Mathematics, in its widest sense, I will define as the science which treats of logical—that is necessary—relations. Between outside things there are no necessary relations. The relation of cause and effect is sometimes called necessary; but, if so, it is not usually handled mathematically. The relations must, then, be of mental things.

They are not relations between images or imaginations of outside things, for two reasons: First, the relations between imaginations can be no more necessary than the things they image; second, the imaginations of men's minds are different. One may imagine a line as a

chalk-line on a blackboard; another, as the edge of a knife; I myself, as the boundary between crystal faces.

However, in all our minds there is something the same in each. It is the concept or idea. And it is of concepts and ideas that mathematics treats.

Here Mill seems to make a mistake. He says, "The points, lines, circles, and squares which any one has in his mind are simply copies of the points, lines, circles, and squares which he has known in his experience." To his mind, then, the function of thought, when we think of circles, is to reproduce some original sensation more or less vividly. This, however, is what I call imagination; and we have tried to prove that imaginations were not the objects of mathematical treatment. Helmholtz acknowledges this when he says that the axioms of geometry, taken by themselves out of all connection with mechanical propositions, represent no relations of real things.

We will notice certain other facts about concepts and words, in connection with their mathematical relations. The first is the persistence of concepts. By this I mean that an idea once formed, by whatever means, experimental or otherwise, does not depend upon the continual recurrence of the same experience for its continued existence.

That is, having once formed an idea of a baby hippopotamus, by having seen one in Barnum's Great Show, I have that idea, which is called into use on various other occasions—such as hearing of it in the newspapers. It is not at all necessary that I should renew the experience every time Barnum comes around. It is, of course, true that a concept may be disused, but its use may be made common as well by unlike as by like experiences.

However, on closer inspection of the hippopotamus, my conception may be new. This leads us to our other all-important distinction and division. Every name has a denotation and a connotation. Its denotation is usually of things, its connotation is conceptual. Some words, proper names especially, correspond to things, the ideas attached to which vary according to the varying aspect of the thing. Other words, however, correspond to ideas; these words are applied or not to things according as there are experiences coming under the concept to which they are attached.

This distinction between words with fixed denotation and varying connotation and words of fixed connotation and varying denotation is quite important, as we shall see. Let us first, however, return to our hippopotamus. This is a word for me of at least partially fixed denotation; it must include the animal that I saw; it must not include an ordinary pig. The connotation would be almost indefinite. This word has, then, a fixed denotation varying connotation, approximately. On the other hand, take the name, rigid body. This is a name with a denotation varying down to zero, perhaps, but its connotation is changeless.

Thus we see that mathematics may be defined as the science of the relations of concepts. Its vocabulary, too, must be one of fixed connotation. That is why symbols are so useful; their connotation does not vary unconsciously.

Benjamin Peirce defines mathematics as the science that draws necessary conclusions. Mill says, "The problem is—given a function, what function is it of some other function?" It is obvious that necessary conclusions can be drawn only so far as there are relations fixed whence to draw them; the function must be given before we find its relations with other functions.

Now, I wish to insist, as strongly as I can, that *any set of concepts become fit for mathematical handling as soon as their relations are unfolded*, and this is what I have so far proved. If you ask, "Whence these concepts?" my answer is, "From experience." From it comes the "element of intuition" that Stallo says is an element in every geometrical axiom. Space itself is but a product of experience. If a man could only hear or taste, would he have our concept of space? I trow not.

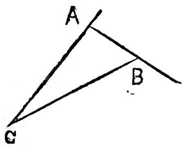
Let us now, after this long digression, return to our transcendentalists. Euclidean geometry and non-Euclidean alike are mathematical. Verbally they come to different conclusions, but neither conclusion affects facts. The difference is here, it seems to me. Transcendental geometry is the offspring of analytic, though some have tried to treat it otherwise. The relations that it handles are at first algebraic relations that may apply to anything. Then applying the geometric nomenclature to algebraic expression, calling expressions of the first degree linear, etc., it interprets these results geometrically. Its definitions, thus, are different from those of Euclid; the ideas connoted by its vocabulary are different; its concepts are not the same. It is not wonderful, then, that it gets a broader field of relations.

We decide, then, that from their respective definitions the Euclidean and the transcendental geometry are true. And this is, perhaps, the most important point to settle, for the transcendentalists have said that, although the geometrical definitions were true, the axioms need not be. We, however, say that the axioms, or what you will, of parallelism, etc., are part of the connotation of the words defined, and are simultaneously given. Of course, some experience is necessary to make us form any concepts.

The question now to be answered is, then, Which are the best definitions? But it must be remembered that, as long as we are dealing with mathematics, we are never dealing with real things. Thus Helmholtz is wrong in saying that by adding any mechanical axioms or principles we can obtain an empirical science out of geometry, if the science thus obtained is purely mathematical.

Mathematical concepts can have two virtues in varying degrees, namely, simplicity and resemblance to, or rather correspondence with,

external reality. First, they must be simple, that is, their relations to one another must be easily handled; second, their relations must correspond more or less closely with the relations of some set of external things. They do not correspond *absolutely*. There are no external things which have the properties of mathematical straight lines except approximately. Take the annexed figure.



One would not hesitate to call A B, B C, C B, straight lines, and to say that the triangle A B C has the sum of its angles equal to 180°. The error he would make (they are drawn with compasses) we always make in kind, though not in degree, in applying mathematics to realities. I wish to make clear that the relation between mathematical truths and external facts is one of resemblance, not identity. What the essence of resemblance is I shall not discuss.

No external facts can do more than change the utility of the two geometries. At present, for simplicity and accuracy of resemblance to external facts, the Euclidean geometry need not fear being swallowed up. If, however, facts should be discovered which could be most simply correlated to transcendental truths, transcendental geometry might become important.

Let us recapitulate. We have tried to show that mathematics deals only with concepts, and that the two geometries are, therefore, also conceptual. Their apparent discrepancy we tried to account for by showing that they used different concepts. We showed that, although concepts might be originated by sensations, they were not, nor were affected by, external facts. The relation between mathematical truths and external facts is one of more or less resemblance, not of identity. Nor can the resemblance be ever proved to be perfect.

The Euclidean geometry has as great facility in accommodating itself to all known facts as the transcendental, and greater simplicity. It is therefore of greater practical utility. The mathematical truth of each is not affected by experience.

Thus transcendental geometry, with its egg-shells turned inside-out without cracking, its knots mysteriously untied, its worlds where the background of everything is a man's own head, is from its conceptual basis, as a creation of man's mind, true. It is a pretty mathematical diversion; it is, as yet, nothing more.

MY SPIDER.

BY W. H. T. WINTER.

A SPIDER, sitting placidly on a hat-peg, awakened in me a vague enthusiasm for natural history; so I captured him, and put him in a bottle. He was lean and gaunt, and had an ominous countenance. The small row of eyes on the vertex of his head looked murder and rapine, and the formidable jaws—which he moved slowly, as if he were sucking his teeth—meant death to those who were his inferiors in strength. He seemed to have been lately in distressed circumstances, for the light came through his very carcass, and his legs were almost as weakly as the gossamer he wove. The strongest part of him seemed to be the stiff hairs that covered him. They stood out independently, and covered his body with such profusion that I was led to call him Esau.

The bottle most likely did not impart a generous warmth, and probably the garish light of day was not pleasant to this denizen of the rafters and remote corners, yet he settled himself in his new habitation with a calmness which commanded my admiration. No fear entered his breast; he was not daunted by captivity. He did not wildly seek an outlet, like most of the things we call insects. He seemed to be of the school of the ascetic Brahmans, and apparently regarded fate as invincible.

"Even if I keep you in captivity," I said, "I will provide you with a mansion, and you shall have an amplicity of food." After a little search a wide-necked jar was obtained, and I set to work to catch flies. The jar was glass, and its mouth was covered with muslin; but in case Arachnida cared not for light and ventilation, I provided him with a piece of paper rolled cone-wise, and in this inner chamber he could seek retirement.

On being placed in his new abode, my friend betrayed no curiosity. He merely settled himself on the piece of paper, as it had a more genial feel than the transparent floor. Perhaps he watched me, but I could not tell that from his expression. His face was typical of indifference.

I now began to make havoc among a colony of flies who had apparently spent their lives in obtaining from the window-panes some occult flavor which is not perceptible to our coarser palates. I made three captives, who were passed beneath the muslin door of the jar with a little sleight of hand. The appearance of these flies was my next subject of observation. They each had an individuality which I did not till then know that flies possessed. Their deportment, their figures, their very moral tone, had a distinct stamp; yet there was an harmonious something which united characters so different. The first

had a fluffy appearance, his body looked sodden, and he behaved in a fat and sensual manner. He took the grossest pleasure in warming his ventral surface on the side of the jar toward the sun. He sipped the sweets of life to excess, and had lost that activity a fly ought to possess. Alas! his career rendered him unfit to battle in the struggle for existence. He became the spider's first meal.

The second fly had but one wing. He was lean and ill-nurtured, yet he had withal a chirpy and pleasing manner. He had neither the pompous bearing of opulence nor the boisterous ways of rude health. He was a sweet-tempered and amiable fly, and among the local muscæ undoubtedly occupied the same position that Tiny Tim did in his family. I should have let him go, only that I feared that, if I did so, I should also release the third fly, whom my soul loathed. Now, let me tell you why that fly was objectionable. He was the only fly left on the window-panes, and he walked over them with the arrogance of a landlord. I sought to catch him, but each attempt was more futile than the last. He dodged, he flew away from the window, he calmly floated about the room, and I followed him, flapping with my pocket-handkerchief till I visibly perspired. He was as cunning as the fox of Ballybogue, who, you remember, used to take in the newspaper to see where the meets were to be. My temper overcame me, and I swore I would have that fly.

After a hunt, which brought out all my worst characteristics, I caught him, and deposited him in my vivarium, rejoicing to myself that his death-agonies would be some compensation for my pains. As soon as he got into the jar, Mr. Fly discovered that his poor little brother in adversity had a raw place where his wing had been torn off, and he would follow him from place to place to put his sucker on to the sore. It was not the kindliness of the dogs of Lazarus which led him to lick the wound. He saw that Tim did not like it, and, as he was a nasty, bullying cad, he persisted in his obnoxious performances. I left him disgusted. He was a beast!

In the course of an hour or so I returned. The sensual fly was in the arms of the spider. The hunter, with his quarry in his clutch, was on the piece of paper, and I could see him well. Four black bead-like eyes, situated on the very summit of his head, gleamed at me with ferocity. His mandibles were stretched to their utmost. The hooked extremity of one was driven into the fly's eye, the other was fixed somewhere about its throat. Between these a pair of jaws were working with a synchronous and scissors-like movement, and his upper and lower lip (for such they were, I afterward learned) worked, as it were, between whiles. As the jaws approached each other, the lips parted. His palps, or leg-like antennæ, waved slowly as the tail of an angry cat; and his very spinnerets, six in number, stood out turgid with excitement. The fly was still, except for a quivering motion of one of its legs. It was the tremor of death.

For ten minutes, at least, the spider did not move a limb. The palpi forgot to wave, and he abandoned himself to the full and gross enjoyment of his meal. I forgot the fly's agonies. This poor starved creature, safe from the persecution of the house-maid, was reveling in the juices of a luscious fly. The gloom of his life was dissipated by a bright spot. Starvation even had a charm when followed by such a meal.

At last he fixed the fly against the paper with one foot, and loosened his grip, and, after giving a sigh of satisfaction, proceeded to decapitate his prey. He then held the carcass in such a manner that I thought he was going to blow into it, but he did not. The pangs of hunger were assuaged, and, with an Epicurean manner worthy of Brillat-Savarin, he sought for some dainty morsel in the chest.

Half an hour after, he still lovingly held his prize, although he ate no longer. The child-rhyme was floating in his memory:

> "Oh, what fun!
> Nice plum bun!
> How I wish
> It never was done!"

I went to bed, and on the morrow another corpse, that of Tim, lay on the floor of the bottle. His expression was placid as in life, and there was that beast of a fly, whom I described before, sucking at the old wound.

Days went on, and Esau's digestion seemed a laborious process. I watched with eagerness to see whether he would lay his hands on his companion by force or fraud. The spider lay immovable, the fly was idly busy in security.

Now, the utter disregard of decency paraded by that fly would have sent a cold shiver down the spine of any proper-minded person. He hustled the corpses of his brethren who were dead. He was constantly trying to extract from their bodies what juices the spider had left. He turned them on their stomachs. He turned them on their backs. He had no regard whatever for the deceased.

I sat in my arm-chair and pondered over the levity of that wretch till the dinner-bell rang, and I went sorrowfully to my evening meal. "How much superior am I to that fly! If a steak from one of my fellow-creatures were laid before me, I should reject it with abhorrence," thought I, "even if it were garnished with the savory onion or the mushroom—ay, even if it were relished with oyster-sauce and the tenderest asparagus. It is only the worst grades of life which can feed upon their kind."

We had chickens for dinner. The liver wing was excellent, and the en-dedans of the back afforded pleasant picking. I begged the maid to preserve the bones for a broken-legged dog whom I had adopted.

My plate was brought on to the lawn, and on it were the remains of the fowls; and the dog was carried out with all care to enjoy his meal on the grass. Poor old thing! His tail wagged with a steady flap, his eyes glistened softly, his neck was outstretched, and his nose was agitated with a delicate twitching till he was placed beside his repast. Then he fell-to, and with admirable judgment selected the most meaty morsels to commence with.

It was lucky that he had finished two pinions, for "the Philistines were upon him." A pea-hen close by heard the crunching. She listened. Curiosity seized her, and she looked at the eater, first with one eye, then with the other. (That was mere coquetry, as it gave her an opportunity of showing off the graceful movements of her neck.) She approached a few steps with stagy dignity; she saw there was food, and the bird of Juno, forgetting her state, ran with an ungainly and slop-slap step toward the plate.

The bird was large and powerful, and the dog was small and an invalid. He therefore secured the best advantages that the circumstances afforded, and sneaked off on three legs with a drumstick.

"Gristle?" quoth the pea-hen; "excellent! Tendon? better still."—Gaup, gaup.—"A small bone? 'twill do me no harm." Down it went.—"A little picking?"—peck, peck.

"Thou cannibal!" thought I, "those are the remains of thy companions of the farm-yard. That fly is not so unnatural, after all. I will let it go."

My resolution was short-lived. Two hours ago there were but a spider and a fly and a piece of paper in the glass jar. Now my friend the spider was evidently getting hungry, and he was exerting himself. Two strong cords were drawn from the paper to the bottom of the jar, and Esau meant business. His spinnerets were turgid, his aspect was determined, and steadily and slowly he commenced to make a web. Now and then the fly took a walk and broke through a strand or two. They stuck to his legs, and annoyed him. With a little difficulty the films were got rid of, but consternation began to seize the fly's mind, and he resolved to move from the scene of operations. He took up his quarters on the muslin which covered the neck of the jar.

Next morning the fly's head hung like a Bulgarian atrocity in the web, his body lay at the mouth of the spider's den. During the night Esau had made a cavern of cobweb.

It is the duty of the historian to adhere to the truth, even if it casts a slur on his favorite theories, and blasts his reputation as an observer.

Esau was not a male: he was a lady.

One day, while feeding the beast, I noticed that the den in the corner had been extended into a passage with two openings, and in the passage wall was a spot thicker and more opaque than the rest of

the building. This I surmised was a deposit of eggs, and I afterward found that I was right.

Still, I had named the animal; and, on the principle of the parson who insisted on christening the little girl John, I adhered to the original appellation. Hitherto the spider had discovered none of the attributes proverbial to her sex, and I did not feel justified in naming her Lucy or Maria.

There were warm days that year, when the air smelled of clover, and flies came out plentifully, and Esau was fed on all available insects that had wings. The house-fly was her staple food, although she regarded small moths as delicacies, and thought midges and small gnats were toothsome articles of diet; but her soul loathed blue-bottles. They were to her what caviare and absinthe are to the uneducated. If a blue-bottle was put into her net she bound it down with many strands of cobweb, and killed it, and, before the animal had ceased to quiver, cast it from her web with evident repugnance. Beetles she did not care for, as they broke her web; but money-spinners she tolerated. Daddy-long-legs fell an easy prey to her, although she did not relish them. That I know, because she never took their carcasses to her cave.

By way of a treat I once offered her a small earth-worm. It wriggled and writhed, lengthened itself and shortened itself, assumed the shape of a corkscrew, and tied itself up into knots. Esau sought refuge in her house, and stuck her head out to watch these strange manœuvres. At first, she was as still as possible; then there was an oscillatory movement of the palpi. She generally did that when she was getting up her pluck. Then she made a rapid rush to within an inch of the worm, and reconnoitred again. She was not satisfied, and retired a second time to think the matter out. The worm, in the mean time, either got tired of struggling, or else philosophically arrived at the conclusion that he could make himself as comfortable in a cobweb as in any other place. The period of rest was fatal. Esau darted on her prey and stuck her mandibles into him. Vainly did the worm try to charm the enemy by tickling her with the end of his tail. Esau held on like a vice. The worm tried to encircle her body with furtive gyrations. Esau had no inclination to play at Laocoon, and eluded the strategy of his prey. That worm gave in.

I began to get tired of my pet. She was getting fat; and the fatter she grew the more ferocious she became. I sought another spider, and found one smaller than the one I possessed. To my mind it was of the same species, but from its size I imagined it was a male. "I will be the historian of the loves of spiders," I said. "Their domestic happiness shall be a moral to mankind. Two spiders together will give me an opportunity of making fresh observations."

I was not disappointed, but my researches gave a result that I had not anticipated.

When I put my finger near the new spider he gathered his legs together, and assumed an abject attitude; perhaps it was a simulation of death. Anyway, the position gave me the idea of meanness and knavery; so I called him Uriah Heep, because he was "so 'umble."

"Esau," I said, with befitting solemnity, "wilt thou take Uriah to be thy wedded husband?" I dropped him into the jar. The lady was sitting in her web; but she bolted into her chamber the moment she felt the impulse of the fresh arrival.

"Ah," thought I, "she is parading her coyness."

Uriah did not seem at his ease, and, leaving the cobweb, he took up a position between the paper and the wall of the jar. Esau protruded what ought to have been her nose—had she belonged to a higher species—from the doorway of her sanctum. There was evident uneasiness on both sides.

Now, I do not believe that these two creatures slept for two days and two nights. They regarded each other with profound suspicion. I put flies into the jar. They would not be allured by food. If one moved the twentieth part of an inch, the other altered its attitude to a similar degree. If Esau wished to get out of her apartment, Uriah occupied a different strategical position. It was a period of brain-tension, watchfulness, and terror.

On the third morning I found Uriah had fallen a victim. His thorax was separated from his abdomen, his legs were disarticulated and scattered, and Esau sat on her perch, placid and contented, the mistress of the situation.

Spiders of both sexes and of every shade of opinion successively shared the captivity of Esau, and they all shared the fate of Uriah. The blood of Mr. Heep had whetted the appetite of the Amazon, and she increased in valor and ferocity. She gauged the strength of her opponent with infallible precision. Now she would use all the arts of strategy; now she would trust to the prestige of victorious arms. Her jar became a very charnel-house of the remains of her kind. A battle occasionally took place, but superior strength and agility made Esau victress. As a rule, however, the new intruder said Kismet the moment it was seized, and resigned itself to fate.

I have yet to relate the most interesting part of my narrative. Pardon me whispering, reader; but Esau has yet to become a mother. The queen of the pickle-jar, who directed the destinies of her subjects—and I must say she directed them in pretty much the same direction—was herself to become the slave of a numerous progeny. It has been an enigma to me who the sire of that progeny could have been.

"No scandal against Queen Elizabeth, I hope?"

Reader, I assure you, my duties are those of a grave historian. I am no carrier of tattle.

It has been an enigma to me (allow me to resume the subject) who the sire of that progeny could have been. Perhaps it was some

spider of ancient lineage, who did valiant battle in his ancestral cobwebs against predatory wasps. Perhaps he had won Esau's young affections, and become master of her charms. Perhaps it was some errant knight, who had vowed the extermination of the whole race of parasites which infest the spider's body. Perhaps it was some wealthy spider, who owned vast demesnes of netting, which extended over many a rafter, and offered hunting-ground for many a retainer. Perhaps her spouse was remarkable for his personal beauty, and had carried off her heart by his comeliness. I know that no spider base-born could have been the father of her offspring. Her behavior to Uriah Heep forbids so gross a surmisal.

Then, how was it that she was alone on the hat-peg? The aristocrat might have spurned her from his home from the prospect of a more advantageous alliance. The enthusiast might have doubted her intensity, and so deserted her. Dives might have been jealous, and have procured an act of separation; Adonis probably spirited away by some light of love.

Her history is open to conjecture alone. The fact remains, that she laid eggs, and they were hatched.

If my memory be not deceived, the small spiders appeared a fortnight or three weeks after I first noticed the eggs. When first born, they were small, yellowy-white, and indefinite, like cheese-mites—just what one would imagine spider-babydom to be. They moved at a pace almost imperceptible from its slowness, and their gait was weak and vacillating. As well as I could make out with the naked eye, they were constantly tumbling on their sides for the first few days. They seemed to meet with obstacles which are not apparent to our gross vision.

I thought the sun would be grateful to them, and their jar was placed on the window-sill. Either the warmth suited them, or baby spiders gain strength rapidly; for, before three days were over, Esau's offspring became marvels of agility. When they were at one end of the piece of paper, urgent business called them to the opposite extremity of the cone, and they ran as fast as their small legs could carry them. If they were on the floor of their home, urgent reasons induced them to promenade the ceiling. Occasionally one little chap would take a long journey around the floor of the jar, while another would start off on a commission of inquiry, and investigate the construction of the cobweb with the minutest care. A third would mount its mother's back, and crawl over her out of sheer curiosity. No pair of them ever seemed to do the same thing at the same time. I never saw them feed; but during the next week or two they increased in size and strength. Esau contemplated them with pleasure; her character was softened. Dozens of flies were put into the jar, but few were killed. Some became entangled and died in the toils, but the majority occupied the top of the jar, and especially affected the mus-

lin doorway, which was moistened for their delectation with sugar and water.

The time for my summer holidays arrived, and I started for the south, leaving Esau to look after the house.

The friendship I had struck up with spiders certainly increased the pleasure of my trip. I found my friends in numbers everywhere I went. They were on the shady side of dock-leaves. They floated in the air and settled on my hat, and were carried off by the next breath of breeze. I found their webs in profusion between the branches of a monkey-tree in the garden; and in the corn-fields myriads of these small creatures trapped flies that were almost microscopic. On the sandy slopes of the sea-shore, cobwebs were among the gorse-bushes. The diadem spiders in the rose-trees vied with each other in the regularity of their nets, and every barn was rich in arachnean architecture. I had heard of water-spiders, and I hunted for them assiduously in every pool and stream in the neighborhood, but with no success. I found no water-spiders, but I became the possessor of many inhabitants of the ponds.

Three weeks passed too quickly, and I had to return to my work and to Esau. Alas! what a lamentable sight met my eyes! Esau was dead, and her children were certainly fatter than when I left. I could arrive at but one conclusion. The dauntless adventuress who had gloried in murder and fratricide had become the victim of misplaced love. Those little wretches whom she had brought into the world, and cared for and nurtured, had turned upon her and slain her and sucked her life-blood. Ah, poor mother, thy antecedents might not have been good! Possibly thou mightest have dined off thy husband or thy paramour—certainly thou hast waged unnatural though valiant war against thy kind; still, that was no reason why thou shouldst have been sacrificed by thy offspring in the bloom of thy maturity.—*Gentleman's Magazine.*

SUDDEN WHITENING OF THE HAIR.

WITH so many professors of the art of rejuvenation proclaiming their readiness to turn old faces into new ones, smooth out wrinkles, obliterate crow's-feet, and restore the hair to its original abundance and color, the putting of young heads upon old shoulders should be easy enough; but the proverbial impossibility of putting old heads upon young shoulders still seems to hold, although the feat has sometimes been accomplished by Nature herself. Sorrow, not Time, frosted the bright tresses of Mary Stuart and Marie-Antoinette; and theirs were not the only queenly heads that have been prematurely

whitened by care and anxiety. While Hanover was waging an unequal contest with Prussia, a lady in attendance upon the consort of the brave, blind king, wrote thus of her royal mistress: "In the last two months her hair has grown quite gray, I may say white. Four months since one could scarcely discern a gray hair; now I can hardly see a dark one."

A similar change has often taken place in the course of a single night. One of the witnesses in the Tichborne case deposed that, the night after hearing of his father's death, he dreamed he saw him killed before his eyes, and found, on awaking, that his hair had turned quite white. An old man with snow-white hair said to Dr. Moreau: "My hair was as white as you see it now, long before I had grown old. Grief and despair at the loss of a tenderly loved wife whitened my locks in a single night when I was not thirty years of age. Judge, then, of the force of my sufferings." His white hairs brought no such recompense with them as happened in the instance of the gay gallant who had the hardihood to hold a love-tryst in the palace grounds of the King of Spain. Betrayed by the barking of an unsympathetic hound, the telling of the old, old story was interrupted by the appearance of the king's guard. The scared damsel was allowed to depart unchallenged; but her lover was held captive, to answer his offense. Love-making under the shadow of the royal palace was a capital crime; and so overwhelmed with horror at the idea of losing his head for following the promptings of his heart was the rash wooer, that, before the sun rose, his hair had turned quite gray. This being told King Ferdinand, he pardoned the offender, thinking he was sufficiently punished.

When the Emperor Leopold was about to make his grand entry into Vienna, the old sexton of St. Joseph's Cathedral was much troubled in his mind. Upon such occasions it had been his custom to take his stand on the pinnacle of the tower and wave a flag as the imperial pageant passed by; but he felt that age had so weakened his nerve that he dared not again attempt the perilous performance. After thinking the matter over, he came to the conclusion that he must find a substitute; and knowing his pretty daughter had plenty of stalwart suitors, the old fellow publicly announced that the man who could take his place successfully should be his son-in-law. To his intense disgust, the offer was at once accepted by Gabriel Petersheim, his special aversion, and the special favorite of the girl, who saw not with her father's eyes. On the appointed day Vienna opened its gates to the new-made emperor; but it was evening, or near upon evening, when the young flag-bearer welcomed the procession from St. Joseph's Tower. His task performed, Gabriel would have descended from the airy height, but found his way barred. Two wretches had done the treacherous sexton's bidding, and closed the trap-door of the upper stairway, leaving the brave youth to choose between precipi-

tating himself on the pavement below, or clinging the cold night through to the slender spire, with but ten inches of foothold. He chose possible life to certain death; but, when rescue came with the morning, his eyes were sunken and dim, his cheeks yellow and wrinkled, his curly locks as white as snow. Gabriel Petersheim had won his bride at a fearful cost.

Believing a fortune might be easily won in the oil-country, a young Bostonian went there to enrich himself. One stormy night a glare in the sky told him that an oil-tank was on fire a few miles off; and knowing that, after a time, the oil would boil up and flow over the side of the tank, he made for a hill to witness the spectacle. "She's coming!" a man shouted. There was a rumbling sound, and then the burning oil shot up from the tank, boiled over its sides, and floated down the creek, destroying everything in its way, and setting fire to a second tank. Curiosity getting the better of discretion, he ran to the ground in the rear of the tanks, to get a better view, and, in trying to avoid a pool of burning oil, fell into a mud-hole, and stuck fast therein. Struggling till he could struggle no longer, he lay back exhausted, watching the billows of smoke surging upward and floating away into space. Suddenly his ears were startled by the sound of cannon-firing; a column of flame and smoke shot up from one of the tanks, and he was stricken almost senseless with the knowledge that the "pipe-line men" were cannonading the first tank, to draw off the oil, and so prevent another overflow. He tried to shout, but the words would not come. A little stream of burning oil ran slowly but surely toward him. He watched it creeping on until it was almost upon him; then in a moment all was dark. When he came back to consciousness he found himself in his own room, surrounded by "the boys," who had seen him just in time to save him. It was a weary while before he was himself again, and then he was inclined to doubt if he was himself, for his once dark hair was perfectly white.

Instances have not been wanting of the hair being deprived of its color in a few minutes. The home-coming of the King of Naples after the Congress of Laybach was celebrated with much public rejoicing. To do the occasion honor, the manager of the San Carlo Theatre produced a grand mythological pageant, in which an afterward well-known opera-singer made his *début* in the character of Jupiter. The stage-thunder rolled, the stage-lightning flashed, as the Olympian monarch descended on his cloud-supported throne. Suddenly screams of horror rang through the house; the queen fainted, and all was uproar and consternation, until the voice of the king was heard above the din, crying, "If any one shouts or screams again, I'll have that person shot!" Something had gone wrong with the machinery before the clouds had descended ten feet, and Jupiter had fallen through. Fortunately, a strong iron wire or rope caught his cloak, and, uncoiling with his weight, let him down by degrees. But

a workman falling with him was impaled upon a strong iron spike supporting the scenery. In ten minutes or so they reached the ground, the workman dead, the singer dazed, but able to thank Heaven on his knees for his escape; and then the awe-stricken people saw that the black-haired deity had become transformed into a white-haired mortal, whose youthful features formed a strange contrast to their venerable-looking crown.

Staff-surgeon Parry, while serving in India during the Mutiny, saw a strange sight. Among the prisoners taken in a skirmish at Chamda was a sepoy of the Bengal army. He was brought before the authorities, and put to the question. Fully alive to his position, the Bengalee stood almost stupefied with fear, trembling greatly, with horror and despair plainly depicted on his countenance. While the examination was proceeding, the by-standers were startled by the sergeant in charge of the prisoner exclaiming, "He is turning gray!" All eyes were turned on the unfortunate man, watching with wondering interest the change coming upon his splendid, glossy, jet-black locks. In half an hour they were of a uniform grayish hue.

Some years ago a young lady who was anxiously awaiting the coming of her husband-elect, received a letter conveying the sad tidings of his shipwreck and death. She instantly fell to the ground insensible, and so remained for five hours. On the following morning, her sister saw that her hair, which had been previously of a rich brown color, had become as white as a cambric handkerchief, her eyebrows and eyelashes retaining their natural color. After a while the whitened hair fell off, and was succeeded by a new growth of gray. This case coming under the observation of Dr. Erasmus Wilson, shattered his unbelief in the possibility of the sudden conversion of the hair from a dark color to snow-white. No man knows more about the hair than Dr. Wilson; but he is at a loss to explain the phenomenon quite to his own satisfaction. "If," says he, "it be established that the hair is susceptible of permeation by fluids derived from the blood—a transmission of fluids from the blood-vessels of the skin into the substance of the hair really occurs, the quantity and nature being modified by the peculiarity of constitution or state of health of the individual—it follows that such fluids, being altered in their chemical qualities, may possess the power of impressing new conditions on the structure into which they enter. Thus, if they contain an excess of salts of lime, they may deposit salts of lime in the tissue of the hair, and so produce a change in its appearance from dark to gray." Then he tells us: 'The phenomenon may be the result of electrical action; it may be the consequence of a chemical alteration wrought in the very blood itself, or it may be a conversion for which the tissue of the hair is chiefly responsible." So many "may-bes" from such an authority prove that the mystery of the sudden whitening of the hair is yet unsolved. It is likely to remain unsolved, since the doctor—more modest than

many of his brethren—owns that "the mysteries of vital chemistry are unknown to man."

The whitening of the hair wrought by mental disturbance is sometimes only of a partial nature. Vexation of spirit gave Henry of Navarre a party-colored mustache. An old writer tells of an Irish captain going to deliver himself up to Lord Broghill, the commander of the English forces, who, being met on his way by a party of English soldiers, was made prisoner, and was so apprehensive of being put to death before Lord Broghill could interfere in his behalf, that the anxiety of his mind turned some of his locks quite white, while the others remained of their original reddish hue. Perhaps the curious change was less annoying to its victim than that which befell an American girl, whose first intimation of her lover's falsity was the reading an account of his marriage in a newspaper. After a night's brooding over the traitor's perfidy, her looking-glass showed her that one side of her head was still adorned with tresses of golden brown; but the other, alas! was decked with locks more befitting a grandam than a maiden still in her teens; though even this was not so bad as was the case of a French girl, who, frightened by the floor of her room giving way beneath her, shed her hair so quickly that in three days' time she was—to use the expressive comparison of a chronicler of the event—"as bald as a bell-handle."—*Chambers's Journal.*

HOW PLANTS RESIST DECAY.

By W. O. FOCKE.

THE destruction and decomposition of organic substances, both animal and vegetable, are promoted by the lower fungoids, particularly by yeast-plants and molds, which we may for brevity call rots. During life, that is, as long as a lively circulation is kept up, plants are protected against the attack of these ever-present organisms, but during the periods of rest, when the life-activity of the plant is reduced to a minimum, defense by the vegetative process is suspended. The older parts of plants, also, in which the normal circulation has become very limited, are poorly fitted to resist decay. It is, therefore, a question how it happens that perennial plants are so rarely attacked by the lower fungoids during their periods of rest.

The best protection is afforded by a firm epidermis, especially if it is fortified against the persistence of moisture upon it by a coating of wax. The importance of epidermal protection is exemplified in the North American opuntias, which bear the Central European winters quite well. If any part of the stalk has suffered an injury which has

destroyed the outer skin, even if only for a very small space, decay begins at the wound, and spreads till it destroys the branch, unless warmer weather quickens growth in the weakened plant, when the process comes to a stop.

The most common protective armor of the higher and woody plants is the cork-bark. The corky substance is of itself extraordinarily tough, and even when dead is only very slowly destroyed by molds. Tree-barks also appear generally to contain chemical substances that operate as poisons upon the lower organisms. The most commonly diffused of such substances are tannin and other coloring-matters allied to it. Many barks also contain strong bitter matters and alkaloids, like salicin, pinipicrin, quercitrin, æsculin, chinin, aricin, strychnin, berberin, etc. The most persistent waxes also reside in the bark, and ethereal oils in individual cases, as in the laurels. The general diffusion of these substances in the bark is the more remarkable because they are rarely found in the wood or the annual leaves.

The subterranean parts of plants need the same protection as the stem. Swamp-plants in particular, which grow in a soil always undergoing decomposition, would fall a prey to decay very quickly without some especial defense. All plants whose organization does not insure them against the action of swamp-soil, perish alike, even under exposure in the winter, at any other time than during the growing season. The under-ground parts of plants growing in such soils are protected in part by the hard epidermis, partly by coloring-matter, as in the alder, comarum, and sanguisorba; or by bitter constituents, as in menyanthes; or by ethereal and aromatic substances, as in valerian and acorus; or by acrid matter, as in frangula and the *Ranunculaceæ*. Antiseptic substances, such as tannin, saponin, and phloridzin, are also found in the underground organs of plants that do not grow in swamps, and the strong essences of the rhizoma of ferns and of the punica-root belong to the same class.

Evergreen leaves, besides requiring means of defense against the lower organisms, need protection against the higher animals, which would consume them during the winter if they were quite accessible and enjoyable. Ulex and Ruscus, therefore, have thorny limbs, smilax and the evergreen brambles and roses have spines on their leaf-nerves, juniper and the holly-leaved plants have thorny leaves. The foliage of yew, arbor-vitæ, ledum, rhododendron, oleander, and laurocerasus is poisonous; and the palatableness of the leaves of pine and spruce, of laurel, ivy, and box, is at least very limited. Only the common underwood, consisting mostly of plants of the heath family, which are to a great extent covered during winter by leaves and snow, contain food for animals in their leaves and twigs. These leaves are likewise defended against rots by the poison in the poisonous kinds, by the hard, bright epidermis in the hollies, and presumably by chemical qualities; the heaths contain a coloring-matter.

Among the fruits, the juicy ones are designed to be eaten by animals, which are to serve as the medium for scattering their seeds. It is, therefore, of advantage to the plant to have its fruit valuable to some animal. The fall season affords an excessive abundance of fruits, but the best and most palatable ones are exposed to speedy destruction. It is, therefore, an advantage to animals, especially to birds, and to the plants likewise, if a few fruits have keeping qualities, that is, are able to resist decay, even if it be partly at the expense of their pleasant taste. This is the case, for example, with the berries of juniper, yew, holly, viburnum, and cowberry, whose persistence appears to depend partly on a hard epidermis, partly on chemical qualities; on an ethereal oil in the juniper-berry, apparently on benzoic acid in the cowberry. Ivy-berries do not ripen till winter.

Seeds are protected by their hard casings or by chemical substances. The poison contained in seeds may in part answer the purpose of preventing their being consumed by animals; but many seeds, as for instance the aromatic seeds of the umbelliferæ and other plants, contain not poisonous but antiseptic substances. The fatty oil, which is so abundantly present in seeds, is perhaps as valuable as a means of protection as for food. The oil as well as the shell of the seed prevents the entrance of water at low temperatures; and, unless water is present, the dry seed can not be attacked by the germs of decay.

If we survey the vegetable products that afford active chemical agents, we shall find that they are predominantly the bark, roots, and seeds. The coloring-matters, the bitter products, the alkaloids, and the poisonous substances are for the most part obtained from these organs. The leaves which afford such powerful matters are generally evergreen. Indeed, there are poisonous plants (among the nightshades, *Araceæ*, and *Personatæ*) and certain poisonous bushes (dogbanes and cashews) which are protected by this quality against the teeth of animals. The ethereal oils serve further in many plants, as among the labiates, the rues, the myrtles, and some geraniums, for protection against the heat of the sun, the reduction of temperature produced by the evaporation of the oils compensating in some degree for the insufficiency of the water which the plants are able to draw from the soil. Aside from these particular cases, however, chemically differentiated substances do not occur abundantly in the leaves or the wood of summer-green plants. Yet a protection of the wood against the germs of decay is evidently not at all superfluous. Wounds are often made upon trees by mechanical injuries, dying limbs, etc., from which decay may penetrate to the interior of the tree. Hence, we quite often find the wood rotten in the interior of a living tree. It is, therefore, also an advantage if the wood is defended against the attacks of rot by its finer texture, by gums, or by antiseptic substances like camphor, quassine, berberin, or columbin.

The great diversity of the chemical combinations that plants, instead of applying for their proper growth, store up in their tissues as a means of protection against the heat of the sun, the lower fungi, or animals, is really astonishing. Even in the liverworts we meet different substances neither the chemical nature nor the biological importance of which is clearly enough known. Among the ferns, only the under-ground stems are endowed with substances of strong qualities. Only single groups among the monocotyledonous plants, and of these the leaves (*Araceæ*) or the flowers (*Melanthaceæ*, lilies) of which show a higher organization, possess acrid poisons or alkaloids or aromatic substances. Among the conifers and dicotyledonous plants the strong substances are very widely diffused in the more enduring kinds.

We have not considered the coloring-matters and odors of the flowers and fruits in this sketch, for they do not serve for protection, but to attract animals.

It is worthy of remark that plants which produce particular substances may be naturalized in regions in which those substances are not required by them. The labiates and rues, which originally belonged to hot climates, still produce ethereal oils in Northern and Central Europe, although they no longer need protection against the hot sun. Closer reflection on the facts we have set forth will show that the real relation must be properly presented as a whole.

Numerous observations, nevertheless, are still necessary in individual cases to make the true significance of each particular phenomenon clear.—*Kosmos*.

THE TOPMOST COUNTRY OF THE EARTH.

By Lieutenant G. KREITLER.

THE name Thibet, as we call that highland, the natural isolation of which gives it a unique position in the world, is not known among the people who inhabit it. The Thibetans call their country Bod, or Bod-yirl; the inhabitants of the northern slopes near the great desert call it Tungut; the Chinese, Si-fan. The highland proper rises in the form of a huge elongated segment of a circle from the adjacent lowlands, and is formed by Nature herself, through the sharply defined rocky precipices that inclose it on every side, into a separate part of the world. The country is bordered on the south by the heaven-aspiring crests of the Himalayan system, consisting of three nearly parallel ranges, the southernmost of which forms the real roof of the Thibetan highland. Impenetrable tropical woods rising from the fever-breeding forest and swamp lands are met at a considerable height by the pine-growths, the whole forming a wonderful panorama; above these rise

the rocky walls bearing in their clefts the eternal ice which glitters and sparkles in the clear sunlight like a gigantic diamond. Similar in structure, but made more imposing by the fact that the steep precipices are planted directly on the untilled plain of the Tarim basin, without any notable intermediate slopes, rises the extreme chain of the Kuen-lun system as the northern boundary of the Thibetan highland. The western boundary is formed by the chain of the Karakorum, with its Triassic and Carboniferous formations, and the furrowed Pamir plain; and the eastern boundary by the curved declivities of the Himalaya system itself, descending with a somewhat more gentle slope toward China. Penetrated by numerous streams which, as a whole, maintain a north and south course, the intervening mountain-regions present formidable impediments to communication. The traveler is overlooked from all directions by icy mountain-peaks that rise to an average height of at least twenty thousand feet. The high table-land itself presents a sad aspect. The enormous height and the climatal conditions dependent upon it restrict vegetation within a narrow limit. No trees are found there, or cultivated fields, no flowers or fruits; and the green spots on which the stunted lavender maintains a precarious existence may be counted among the broad basins filled with gravel and pebbles. The winds bring no moisture. The sparse snow-falls of the year are not enough to impart productivity to the earth, and the plateau is nearly destitute of animal and plant life.

The Thibetan settlements are almost entirely situated in the valleys of the larger rivers, which the relatively lower situation, the higher degree of moisture in the atmosphere, and the possibility of irrigation enable the inhabitants to bring to a measure of tillability. A certain degree of fertility of the soil of the capital can not be denied. Two principal rivers have their sources at a nodal point in the Himalayas, whence they cross the more southern country and India from left to right. They are the Indus in the west and the Sampo in the east. The course of the Indus is well known and marked, but all that has been ascertained of the Sampo is that it maintains a nearly easterly course to southeast of Lassa, after which it is still in doubt whether it becomes the Brahmapootra or the Irrawaddy.

The climate is very severe. The temperature in winter often falls to from 13° to 22° below zero; all the rivers and lakes are covered with ice as early as November, and even in April the sun has not acquired vivifying force enough to melt their crystal surfaces.

No European is allowed to pass over the southern boundary of this country. The East Indian Government has made several attempts to gather information about it, but has been baffled. Colonel Montgomery, a few years ago, conceived the idea of instructing young Indian Buddhists in geography, and sending them to Thibet in the guise of natives. Carrying only indispensable instruments with them, they have been exploring the plateau since 1865, and have till recently

returned regularly to India with valuable information. The suspicion of the Thibetans was, however, at last aroused, and a pundit sent in 1879 was not allowed to reach Lassa, but, some of his words having been overheard and his mission divined, he was compelled to flee, leaving most of his baggage behind him. An imperfect map of the country was made in the beginning of the eighteenth century, by order of the Emperor of China, with the aid of the Roman Catholic missionaries, but its data rest upon report rather than upon the results of actual observation. It has been, however, the foundation on which all our maps of the region have had to rest.

The Thibetan legend of the origin of the people is that, in the beginning, only one man and his three sons lived on the table-land. They had no houses or tents, but led a migratory life, without being troubled with the cares of existence, for the land was not then desert, or poor, or cold. Trees were growing which afforded choice fruits, rice flourished without man having to labor to raise it, and the tea-plant thrived in the fields that Buddha afterward changed into stony places. Thibet was then all the more a fortunate, rich land, because these four men, then the only living creatures in the world, knew nothing of war and contention, but lived in unity and peace. At last the father suddenly died. Each of his sons wanted his body, to dispose of it in his own way. This was the first dispute. The corpse lay for some days on a large rock, and the sons avoided one another. At last the eldest son made a proposition: "Why should we be alienated because a misfortune has happened to us all in common? Let us be agreed, and divide the body." They all accepted the proposition. The corpse was divided into three parts, and each son took a part. The eldest son got the head. He went away toward the east, and became the father of the Chinese, who excel in craft and have great skill in trade. The second son was satisfied with his dead father's limbs. He also left his home and settled where the great Desert of Gobi gives his posterity, the Mongols, plenty of room; their characteristic is restlessness. The youngest son received the breast and bowels. He remained in Thibet, and from him are descended the Thibetan people, who are distinguished in ordinary intercourse by good nature, openness, and cordiality, in war by courage and enthusiasm.

The knowledge that Ptolemy had of the country consisted of obscure sketches which were closely connected with stories of the Chinese capital. Herodotus tells something of the wealth of the land in gold. He says that the gold was found by ants and collected by them into large heaps which were guarded by griffins; and he also tells that a number of Hindoos once got into the country at night when the guardians were asleep, gathered up as much gold as they could carry away on their shoulders, and went back to their homes rich.

The expedition of Count Szechenyi, to which I was attached as a

geographer, was permitted, a little more than a year ago (in 1880), to add a little to our geographical knowledge of the eastern part of the Thibetan highland, particularly of the table of Chung-yen, where no European had ever before penetrated. The priests used every means in their power to prevent our carrying out our project of going to Lassa; and, when they at last came out against us with a thousand soldiers, we were compelled to leave the main road and force our way to the south.

The Thibetans belong to the great Mongolian race, but they are distinguished in many respects, and to their advantage, from their congeners, the Mongols proper and the Chinese. The external characteristics which they have more or less in common with them are the small black eyes, the prominent cheek-bones, the flattened nose, large mouth, and thin lips. They are, like all mountaineers, stout and strong. When I saw Thibetans for the first time at Ta-tsien-lu, I was prepossessed with them. They had come down out of the high mountains and wild clefts expressly to see us Europeans. The contrast between them and the Chinese was made clear not only by their imposing appearance, but also by their earnest quietude and the grave demeanor they maintained in the midst of the crowd of shrieking and boisterous Chinese townsmen. These robust, muscular figures, with weather-browned, wrinkled, thin, earnest faces, were the people called "wild" by the Chinese; and their black, deep-set eyes, framed in a tangled forest of straggling hair, glowed with the fierce fire of religious fanaticism.

The men are always armed, if not with a Chinese matchlock, with the sword of their country, a weapon often of marvelous workmanship, having the hilt adorned with turquoises and the sheath richly chased. Every one wears on his breast, as an amulet against evil spirits, a casket of gold, silver, or copper, containing various forms of incantation. The women and girls, with their two braids of raven hair, their brightly colored, chubby cheeks, their ample drapery, and their precious ornaments of metal and jewels, drive their puny Chinese rivals quite out of the field of comparison. Variety rules in the Thibetan dress, particularly in the arrangement of the women's hair. Sometimes it is worn in two braids, sometimes re-enforced with great structures of yak-hair; always, if the wearer is able, adorned with jewels, silver ornaments, or strings of coins. The women's faces are never clean, but the custom prevails of soiling them purposely.

Their dwellings are situated, either scattered or in little hamlets, wherever tillable soil can be found. Their houses rather resemble defensive towers than residences: they are made of drift-stones, of one story or more, and are expected to accommodate the domestic animals as well as the family; and, if the house is of one story only, the arrangement is apt to be rather promiscuous. The separation is more effective if the house has an additional story; but in the houses of

the better class the only means provided for the family to reach the upper stories are split trunks of trees, with notches for steps cut in the round side. The rooms are dark and gloomy, well ventilated through the half-stopped chinks in the walls, with a fire in the middle of the floor, and light bunks or the floor itself for beds, but innocent of any other furniture except a low table and two or three skin mats; chairs and benches are known only by hearsay. The only roof is a flat platform over the rooms, on which the crops are spread in dry weather and the inhabitants sun themselves in the winter, and where a shrine of Buddha is often erected. The nomadic, cattle-raising Thibetans live in tents, which they weave from the hair of their domestic animals.

The Thibetans are pleasantly disposed, and intercourse with them would be cordial and agreeable were not the free development of their natural traits restricted by the pressure of their religion. Frank and hearty in word and deed and in everything that is not connected with religion, generous in intercourse and in trade with the crafty Chinese, they always come out second best when they have dealings with them. They are brave soldiers and feared as such, but are never cruel. The men are fond of gymnastic exercises, and try their strength together at every opportunity. They are excellent pedestrians and horsemen, and are extravagantly proud if they can boast of having the best horse in the place. As porters they have wonderful powers of endurance. While we Europeans, suffering in the thin air of an elevation of seventeen thousand feet, had to stop often to recover our breaths, I could not but envy our Thibetan bearers, who kept on up the heights with their heavy loads, as often as not singing. Their social intercourse is marked by sharp, sprightly wit and humor; but some of the upper classes ape the artificial courtly manners of the Chinese.

The principal food of the country is called *jamba*. To make it a quantity of powdered tea is cooked for several hours, after which it is poured into a churn, when salt and butter are added, and the whole is stirred till a complete mixture is effected. The broth is then divided among the hungry ones, each of whom gets his share in a wooden bowl, after which a sack of roasted barley-meal is brought out. Every one takes a handful of meal from the sack, puts it into the tea and mixes the mass into a shapely lump, and swallows his dough with a keen appetite. I have seen a Thibetan devour thirty-two of these lumps in an hour. The preparation of this meal makes it possible for each Thibetan to have his hands washed twice a day. After the meal is over, the wooden bowls are licked clean with the tongue, and worn on the breast next to the skin as something precious.

Polyandry is practiced, not on account of any lack of women, for there is no such lack, but as a measure of economy. When the eldest son marries, his wife becomes also the wife of all his brothers. The

custom does not lead to so many difficulties as it might be supposed it would, and the chief troubles arising out of it concern the fatherhood of the children. The housewife occupies rather a commanding than a subordinate position.

Three ways of burying the dead prevail. The poor sink their dead in one of the mountain-streams; those of a better class hang the bodies upon a tree, where they are consumed by birds, and the bones are afterward thrown into the river; the rich cut the bodies up into small pieces, pound the bones and mix them with *jamba*, and then carry the remains to the mountains, where they are left for the birds. These are old customs, and have no connection with religion.

Buddhism was introduced in the seventh century, and soon became the national religion. The present line of Dalai Lamas is in succession to the reformer Tsong-Kaba, who flourished in the fourteenth century, and denounced the corruptions into which the religion had fallen. The branch of the church which it represents is called the yellow sect, in distinction from the red sect of followers of the old dynasty, which prevails in the principalities of the southern Himalaya range. A dynasty of lamas, the Teshu lamas, founded by another reformer in the fifteenth century, resides at Teshulumbo, near Shigatze, and is on the best of terms with the Dalai Lamas. The lamas are believed only to change form when they die, their identity passing to some child. So, on the demise of the Dalai Lama, the new lama is sought out in ways that are known to the priests, and is always found in some obscure family, thus leaving people of any influence always free from governmental care and influence. He is carefully brought up, so as to be always as a child, and under the entire control of the priests, who receive their reward in the power they exercise, and in the rich gifts that are brought by the pilgrims who come from all Buddhist countries to seek the Dalai Lama's blessing. Besides the two orthodox chiefs, there exist in Thibet and Mongolia one hundred and three Kutuktus, or heads of cloisters, to whom an immortality similar to that of the Grand Lamas is ascribed.

The priests, by virtue of their ownership of all the land in the country, exercise a despotic power over the people, who can hold only as their tenants, and keep them under complete spiritual control. They are thus enabled to keep the country isolated, and to defy the Chinese Government, while they are willing and even anxious to enjoy its protection.

SKETCH OF BARON ADOLF ERIC NORDENSKIÖLD.

BARON NORDENSKIÖLD has been styled by Germans the Vasco de Gama of our century. His work is solid and original enough to stand by itself, and need not be compared or contrasted with that of any other. The careful, systematic pursuit of a well-formed purpose, with the full benefit of the experience of past navigators, with a well-defined idea of what was expected to be accomplished, and of how it was to be done, with scientific foresight displayed at every step, can not with justice to either be weighed in the same scale with the bold achievements of the hardy adventurers of former centuries who, starting without the aid of any of the knowledge which has now been accumulated, and without definite notions of where they should go or what they would find, discovered what the fortunes of the wind and the waves brought in their way. The character of Nordenskiöld's work and the manner in which it was performed mark, however, the difference in the methods of research which were available in the past and those which we enjoy and employ at present. In this sense only can a just comparison be made between Nordenskiöld and the explorers of other centuries.

Baron Nordenskiöld is not only a most successful Arctic explorer and navigator, as he is best known: he has done excellent work in other branches of science, and has contributed to knowledge from many directions; and the pages of his narratives of voyages bear evidence to the fact of his versatility, that no event or thing that may add to knowledge is unobserved or unemployed by him; that he knows how to lay all under contribution for the advancement of knowledge. What is most attractive about him, says Dr. Karl Müller, of Halle, "is not the splendid achievement of his polar journeys, but the irrepressible perseverance with which he exerted himself through years at a time to pass from small beginnings to ever bolder and more practical problems. While the navigation of the northeast passage may always be regarded as the brightest among his discoveries, Nordenskiöld was, through all his previous history, a whole man."

Baron Nordenskiöld enjoyed the advantage of an ancestry distinguished through several generations for scientific attainments. "Nature" says, in its biography of the explorer: "The race from which Nordenskiöld sprang had been known for centuries for the possession of remarkable qualities, among which an ardent love of nature and of scientific research was predominant. Its founder is said to have been a Lieutenant Nordberg, who was settled in Upland about the beginning of the seventeenth century. His son, Johan Eric, born in 1660, changed the name to Nordenberg. He died in 1740, leaving two sons, Anders Johan and Carl Frederik, both of whom, though the

latter was only lieutenant, were elected members of the Swedish Academy of Sciences when it was founded in 1739. Carl Frederik is the common ancestor of the families bearing the name of Nordenskiöld now living in Sweden and Finland. One of his many remarkable sons, the third in order, Colonel Adolf Gustaf Nordenskiöld, became owner of Frugord, in Finland. This property, situated in a forest-crowned valley in the department of Nyland, is still in the possession of the Nordenskiölds. Here Colonel Adolf Gustaf Nordenskiöld built a peculiar residence, the middle of which is taken up with a hall two stories high, round the upper part of which runs a broad gallery, in which collections in natural history are arranged. His youngest son, Nils Gustaf, was born in 1792. After passing his examination in mining at the University of Upsala, he was for several years the pupil of Berzelius, with whom he formed the warmest friendship, which was only broken off by death. Nils Gustaf, early known as a distinguished mineralogist, was appointed a government inspector of mines in his native country, and, by means of liberal grants of public money, was enabled to undertake extensive foreign tours, which brought him into communication with most of the eminent mineralogists and chemists of the day in England, France, and Germany. After three years of foreign travel he returned to Finland, and was promoted in 1824 to be chief of the mining department, and devoted thirty years of restless activity to the improvement of that important branch of the industry of his native land. He traveled through Finland in all directions, in the prosecution of his untiring mineralogical and geological researches. His travels extended as far as the Ural. He published his views, discoveries, and experiments in many scientific periodicals and in several independent works, and a large number of minerals discovered by him afford evidence of his keen research. He was made Councilor of State, and obtained many distinctions for his scientific services from the sovereign and from learned bodies. On February 21, 1866, he ended his active life."

Adolf Eric Nordenskiöld, the son of this Nils Gustaf, chief of the mining department of Finland, and of his wife Margaretta Sofia von Haartman, was born at Helsingfors, Finland, November 18, 1832, the third in order of seven children. In his boyhood he was an industrious collector of insects and minerals, and was permitted to accompany his father in mineralogical excursions. Under the guidance of his father, who, a pupil of Gahn and Berzelius, was an expert in those matters, he acquired a skill in recognizing and collecting minerals which proved of great service to him in the path of life he afterward followed, and in the use of the blowpipe. He subsequently undertook the charge of the rich mineral collection of Frugord, and made vacation tours, which were of great benefit to him. He studied for some time with a private tutor, and was then sent to the gymnasium at Borgo, where, according to his own accounts, he enjoyed an almost

unlimited freedom, the teachers showing no inclination to meddle much with the occupations of their pupils. He entered the University of Helsingfors in 1849, and devoted himself chiefly to the study of chemistry, natural history, mathematics, physics, and particularly mineralogy and geology. Having passed his candidate examination in 1853, he accompanied his father on a mineralogical tour to the Ural. In this expedition, according to Professor Fries, of Upsala, was unconsciously laid in him the beginning out of which his later expeditions grew. "It was an instance of the old eagle teaching the young one to fly." After his return from this excursion, Nordenskiöld continued to prosecute his chemical and mineralogical studies with zeal. The subject of his dissertation for the licentiate, "On the Crystalline Forms of Graphite and Chondrodite," which was delivered on the 28th of February, 1855, bore relation to them. During the following summer he was engaged upon a description of minerals found in Finland, which was published in the fall. Various short papers on mineralogy and molecular chemistry were published in the "Transactions of the Finnish Scientific Society," and a paper on "The Mollusca of Finland" was published by Nordenskiöld, along with Dr. E. Nylander, in 1856, in response to a prize question proposed by one of the faculty of the university. While these studies were being prosecuted, young Nordenskiöld had been appointed salaried curator of the mathematico-physical faculty, and had obtained a post at the mining office as mining engineer extraordinary, with inconsiderable pay, and an express understanding that no service would be required from him in return. He lost these positions in consequence of having been present at a festival where too much freedom was given to the expression of political feelings, and spent a few months abroad, working a part of the time at Rore's laboratory in Berlin at researches in mineral analysis. Returning to Finland, he secured a stipend for a line of study through Europe in 1857; but at the "Promotion Festival" in that year, where he was to take his master's and doctor's degrees, more liberal views were aired, which Von Berg, the governor of the Duchy, considered treasonable, and Nordenskiöld left Finland again, this time not to return as a fixed resident. The displeasure of the Government against him was not, however, of long continuance, for he has been welcome in Finland since 1862, and he might have been appointed Professor of Mineralogy in the University of Helsingfors, had he been willing to agree to give up politics. He became naturalized in Sweden, and soon rose to eminence in public life and in science.

The Arctic voyages of Baron Nordenskiöld began in 1858, when he took part in the Swedish expedition to Spitzbergen under Torell, the chief of the Swedish Geological Survey. On his return, he was appointed successor to Mosander in the Riks Museum at Stockholm, where he immediately went to work, partly at the arrangement of the museum, partly at the scientific researches which formed the subjects

of several papers that were published in the "Transactions" of the Academy of Sciences and of the Geological Society. He made constant endeavors to enlarge the collections, with the result that by the aid of the Swedish mineralogists and of the students, who co-operated with him, and in consequence of the extraordinary richness of the Scandinavian Peninsula in rare and valuable minerals, the cabinet has become one of the most considerable in Europe.

In 1861 he took part in the second expedition of Torell to Spitzbergen, expecting with that to end his excursions toward the pole, and with that view married, in 1863, a Finnish lady, Anna Mannesheim, daughter of ex-President Count Carl Mannesheim. He had, however, already, in December, 1862, crossed on the ice from Sweden to Finland, in order to make some investigations on the formation of sea-ice; and in 1864 he went with the third Swedish expedition to Finland, the business of which was connected with the measurement of the arc of the meridian. His destiny to become an Arctic explorer seems to have been settled with this enterprise, and from it may be dated the beginning of a purpose to conduct explorations on his own account and after his own plans. The next year found him engaged in mineral investigations in Sweden and Finland. In 1867 he went to Paris as a member of the International Metric Commission, attended the Exposition, and made the acquaintance of the men of science of the south.

In 1868 Nordenskiöld went out as the head of the fourth Swedish Arctic expedition, to which Mr. Oscar Dickson, the patron of his later voyages, first gave his generous aid. In this voyage he sought to get as near to the pole as possible, and the sensational achievement of it was that the Sophia reached a higher latitude (81° 42′) than had been attained by any vessel in the old hemisphere. Far more scientific importance is attached to the fact that the expedition brought home a rich collection of the fossil plants of the Arctic regions, concerning which but little had previously been known. Another expedition, in which Nordenskiöld was accompanied by Dr. Berggren, was dispatched to Greenland in 1870, having for its principal object to ascertain whether the Esquimau dogs could be relied upon for long sledge-journeys. This question was decided in the negative, but the expedition brought forth scientific fruit second in value to that of no other single one, in that it gave an opportunity to the brave student who led it to examine the remarkable ice-formation of the interior of Greenland, and that it led to the discovery of the celebrated large blocks of meteoric iron of Ovifak, concerning the origin of which a lively scientific controversy has arisen, and which, the explorer himself suggests, may at some future time "form the starting-point for quite a new theory of the method of formation of the heavenly body we inhabit."

Concerning the ice-formation, Baron Nordenskiöld has written:

"An excursion of some length was made into the wilderness of ice, everywhere full of bottomless clefts, which occupies the interior of Greenland, and which, if I except unimportant wanderings along the edge, and an inconsiderable attempt in the same direction in the year 1728, by the Dane Dalager, was now, for the first time, trodden by human foot. I had here an opportunity of clearing up the nature of a formation which, during one of the latest geological ages, covered a great part of the civilized countries of Europe, and which, though it has given occasion to an exceedingly comprehensive literature in all cultivated languages, had never before been examined by any geologist."

Another expedition, of two vessels, was fitted up in 1872, with the design of attempting to reach the pole with reindeers, to which Lieutenant Palander, the companion of his last voyage, was for the first time attached. The ice was unusually unfavorable, and the winter was spent in Mussel Bay, on the north of West Spitzbergen. Here attention was first called to the presence of dust of cosmic origin containing nickel-iron, the agency of which as a possible factor in building up the earth's crust is discussed with considerable fullness in the "Voyage of the Vega"; more complete researches on the aurora and its spectrum were carried on; investigations were made on the development of algæ during the winter night of four months; numerous new contributions to a knowledge of polar countries during former geological epochs were discovered; and a complete series of meteorological and magnetic observations was made in the most northerly latitude where such observations had up to this time been carried on. With this expedition Nordenskiöld's efforts to reach the pole ceased. He had become convinced by his repeated voyages that there was no open sea at the pole; and he had his attention drawn to the "more practical problem, which had interested the foremost commercial states and the most daring navigators for three hundred years, and geographers for thousands of years"—that of forcing a northeast passage to China and Japan, and the circumnavigation of the Old World.

In 1875 he succeeded, with the walrus-hunting sloop Proeven, in sailing over the Kara Sea as far as to the mouth of the Yenisei, whence he put himself in communication with the river-steamers to Yeniseisk; and whence he returned by land, while his companions came back by sea to Europe. By this voyage, he says, "I was the first person who succeeded in penetrating from the Atlantic Ocean in a vessel to the mouths of the great Siberian rivers. One of the objects which the old northeast voyagers had aimed at was at last accomplished, and that in a way that promised to be of immense practical importance for the whole of Siberia. The voyage was also regarded in that light by leading men of the great empire of the East, and our return journey from Yeniseisk by Krasnojarsk, Tomsk, Omsk, Yekaterinburg, Nizhnee-Novgorod, Moscow, and St. Petersburg became, therefore, a jour-

ney from *fête* to *fête*. But a number of voices were simultaneously raised, which asserted that the success of the Proeven depended on an accidental combination of fortunate circumstances which would not soon occur again. In order to show that this was not the case, and that I might myself bring the first goods by sea to Siberia, I undertook my second voyage to the Yenisei in 1876, in which I penetrated with the steamer Ymer, not only to the mouth of the river, but also up the river to Yakovieva in 71° north latitude. Hence I returned the same year by sea to Europe."

Between these two voyages, Baron Nordenskiöld found time to visit our International Exhibition at Philadelphia, in connection with which his name is recorded as one of the judges in the group of pottery, glass, artificial stone, etc., and as an exhibitor of maps. "And it may deserve to be mentioned," he says, "that, leaving New York on the 1st of July by one of the ordinary steamers, and going on board my own vessel in Norway, I reached the mouth of the Yenisei on the 15th of August—that is to say, in forty-six days."

The voyages of the Proeven and the Ymer led to several purely commercial voyages to the Yenisei and the Obi. After his return from the second voyage, he became fully satisfied, in the light of his own experience and of the old explorations of the north coast of Asia, that the open navigable water, which for two years in succession had carried him across the Kara Sea, formerly of so bad repute, to the mouth of the Yenisei, extended in all probability as far as Behring Strait, and that a circumnavigation of the Old World was thus within the bounds of possibility.

He conceived the idea of a new voyage, the purpose of which was to pass through the whole extent of the Arctic Ocean to Behring Strait, and thence around the continent back to Stockholm. He solicited an audience with the king, the scientific men, and Arctic voyagers of the country. It was given him on the 27th of January, 1877, and he came to it fully prepared with a statement of his purposes and his reasons for considering them feasible. Besides "the world-historical navigation problem," which would be solved by the success of the enterprise, he suggested that "extensive contributions of immense importance ought also to be obtainable regarding the geography, hydrography, zoölogy, and botany of the Siberian polar sea; and beyond Behring Strait the expedition will meet with other countries having a more luxuriant and varied nature, where other questions which perhaps concern us less, but on that account are not of less importance for science as a whole, will claim the attention of the observer and yield him a rich reward for his labor and pains."

He received the encouragement and aid he asked for, and was able to sail in July, 1878, on a new expedition, the complete success of which is a matter of history, and the ultimate results of which, in the opening of new branches and lines of trade, and the bringing to pos-

sible productiveness of an immense region hitherto supposed to be consigned to the dominion of ice, can not as yet be adequately estimated.

The value of his work was appreciated by the people with whom he came in contact during the course of the voyage. On the arrival of the expedition of 1875 at the Lena, the Dolgans at that remote spot on the border of the tundra, "when they understood clearly that we had come to them not as brandy-sellers or fish-buyers from the south, but from the north, *from the ocean*, went into complete ecstasies . . . . At Dudino, also, the priests living there held a thanksgiving service for our happy arrival thither." The voyage home, around the Pacific coast and by the Indian Ocean and Suez Canal, was marked by a series of festivities given at every point where the Vega touched. At Yeddo the navigators were greeted with deputations, bearing addresses of welcome and invitations, and were given a lunch with the Mikado, and a special audience with his Majesty. Similar scenes were repeated, with such variations as circumstances made appropriate, at Hong-Kong, Cairo, Naples, Lisbon, Paris, Copenhagen, and Stockholm. At Naples, the expedition was welcomed back to Europe by the representative of King Oscar of Sweden, who also conferred Swedish decorations on Baron Nordenskiöld and Lieutenant Palander; an Italian officer came down from Turin commissioned by the Government, and bearing the welcomes of several municipalities and scientific societies, with Italian orders for the men of the Vega. At Lisbon, in addition to the usual audiences and receptions, the Portuguese Chamber of Deputies voted a welcome and a congratulatory address. Circumstances prevented the public demonstrations which had been arranged for in England from being held, but the visit of Nordenskiöld and Palander to London was made pleasant by the hospitality of the most distinguished scientific men of the kingdom. At Paris a public reception was given by the Geographical Society; the commanders' and officers' insignia of the Legion of Honor were conferred by the Minister of Education, at a meeting of the delegates of twenty-eight learned societies held in the Sorbonne; a welcome was given by the Institute followed by a festive reception by the Municipal Council; numerous dinners were eaten, and medals were liberally distributed. Invitations to Holland and Belgium had to be declined "from want of time and strength to take part in more festivities." The entrance to Stockholm was made through a thick fleet of excursion-steamers gayly decorated, and under a brilliant illumination of the city; and, after the first enthusiastic welcomes, "*fête* followed *fête* for several weeks." Writing of this expedition, Dr. Karl Müller says, in "Die Natur," that "among the most recent voyages none has been so splendidly planned, none undertaken with such noble means and pursued with such eminent scientific success as the circumnavigation of Europe and Asia by Nordenskiöld

and his companions." Of the series of voyages to Spitzbergen, "Nature" says: "These expeditions were not undertaken for the mere purpose of creating a sensation by the foolhardy feat of attempting to reach the pole at all hazards. Geographical discovery certainly formed a part of the programme of all the expeditions in which Nordenskiöld has been engaged;" and it contrasts the results—of the first importance, and obtained with a modest expenditure—strongly with those of "the expensive and elaborately equipped expedition in the Alert and Discovery." Speaking in 1879, while the last expedition was still in progress, "Nature" said, "Comparatively young as Professor Nordenskiöld is, he has done an amount of work rarely accomplished even in a long life-time." And in February of this year, reviewing his whole work, it said: "Thus no one man has done half so much as Baron Nordenskiöld for a scientific exploration of the Arctic regions. The most striking characteristics of his various expeditions have been the small expense at which they were conducted, their modest but carefully considered equipment, the clear and scientific methods on which they were planned, and the wealth and high value of the results obtained." Baron Nordenskiöld is now preparing for another expedition.

Baron Nordenskiöld represented the capital of Sweden in the Diet from 1869 to 1871, and was instrumental in bringing about some important legislative measures for the promotion of science.

Personally, Baron Nordenskiöld is a genial man. His modesty and aversion to public display, which are well known and recognized, are quite remarkable in his "Voyage of the Vega," where he shuts his personality wholly out of sight, and devotes his attention, with an exclusiveness which is rare among travelers, to the account of what he observed and learned. Yet he loses no occasion to introduce his companions and their labors, and to give them full credit. So complete is his sinking of himself that it has been impossible to find anything in that work with which to illustrate his personality for the purposes of this sketch.

ENTERTAINING VARIETIES.

— Says "Blackwood's Magazine": "The man who first suggested an electric telegraph, in a letter to the 'Scots Magazine' in the year 1745, Charles Marshall, was looked on as having dealings with the Evil One, and had to leave his native country and go to America. When Ronalds, about the year 1817, laid his plans for an electric telegraph before the English Government, they would not even take the trouble to investigate the matter. An under secretary, in the usual official style, wrote him that he was 'directed by his Majesty's Secretary of State, etc., to inform Mr. Ronalds that a telegraph is of no use in time of peace, and that in time of war the semaphore then in use was quite sufficient for the purpose.'" And as late as 1879 one of the "most able and experienced electricians of the day" was in a state of mind to say before a select committee that he did not think the telephone would be much used in England; that he fancied the descriptions they got of its use in America were a little exaggerated; "but there are conditions in America which necessitate the use of instruments of this kind more than here. Here we have a superabundance of messengers, errand-boys, and things of that kind. In America they are wanted."

— *Tanner*, in his narrative of a captivity among the North American Indians, says that, when a certain chief named Picheto was one night much alarmed by a furious storm, he got and offered some tobacco to the thunder, entreating it to stop.

— *Prisons as Clinics.*—Dr. Maudsley remarks: "Another promising but strangely neglected field of inquiry is a study of *criminals*. The time will come, ought to have come now, when prisons shall be used for the systematic investigation of the antecedents, and for the clinical study of the varieties of the criminal nature, just as asylums are used for the clinical study of diseased minds, hospitals for the study of diseased bodies. It may not be doubted whether half the books that have been written on moral philosophy would be worth one good book, by an earnest and industrious inquirer, who should undertake the scientific study of the inmates of a single prison."

— *Max Müller* says, in his sketch of *Kant*, that for the last twenty years of his life he always had guests at dinner—two to five—that he demanded punctuality, that the guests proceeded to the dining-room talking of no subject more profound than the weather, that politics (and we may add science, natural history, etc.) was a frequent subject of conversation, but anything of the nature of metaphysics was rigorously excluded. Though of a very slender constitution, all his life through Kant had managed to keep himself in health by persistent adherence to certain maxims of diet and regimen. One of these was that the germs of disease might often be avoided if the breathing were systematically carried on by the nose; and for that reason Kant always in his later years walked alone with mouth closed. He was also careful to avoid perspiration. He walked after dinner alone, and then attended to business or read newspapers and miscellaneous books. As the darkness began to fall, he would take his seat at the stove, and, with his eye fixed on the tower of Lobenicht church, would ponder on the problems which exercised his mind. One evening, however, as he looked, a change had occurred—the church-tower was no longer visible. His neighbor's

poplars had grown so fast that at last, without his being aware, they had hid the turret behind them. Kant, deprived of the material support which had steadied his speculations, was completely thrown out. Fortunately, his neighbors were generous—the tops of the poplars were cut, and Kant could reflect at his ease again.

—— The manuscript of Mill's "Logic" was first sent to the publisher Murray, who, after keeping it so long as to occasion a year's delay in its publication, declined it. It was next offered to Parker, who accepted it, and sent the opinion of his referee, in the writer's own hand, withholding the name. "He forgot," said Mill, "that I had been an editor, and knew the handwriting of nearly every literary man of the day." The referee was Dr. W. Cooke Taylor, who afterward was one of the reviewers of the book.

—— *Carriage-Fares in New York and London.*—A writer in the "Tribune," describing the carriage system of large cities, says: "Briefly put, the legal rates for cabs and carriages in New York are fifty cents a mile and fifty cents a half-hour, with no fare less than one dollar. In London the cab rate is twenty-five cents for any distance under two miles, and thirteen cents for each additional mile; just one fourth the rate in New York." Who would live under monarchical extravagance, when they can have republican simplicity at four times the price?

—— *Infinitesimal Scale of Molecular Systems.*—Life is a stream of attributes that flows along from generation to generation, each kind being, as it were, a special channel for special characters. But the everlasting wonder is, how all the characteristics of a species can be embodied in a germ so as to be reproduced by growth; and still more amazing is it how the nicer shades of organic modification are also transmitted by the germ so as to become hereditary. In some way the systems of organic molecules must be capable of taking and retaining an infinite number of inconceivably delicate impressions; for with the myriad forms of life there must be formed myriads of molecular modifications of germ structure. Dr. Flint says that the head of a human spermatozoön is $\frac{1}{5000}$ of an inch long, $\frac{1}{8000}$ of an inch broad, and $\frac{1}{25000}$ of an inch in thickness; and Professor Du Bois-Reymond says if this head is assumed to be as large as the Great Eastern, and packed throughout with machinery as fine as the finest ladies' watch, even this would fail to represent the fineness of the system of molecular machinery that actually fills the head of the real spermatozoön.

—— According to *Mr. Lockyer*, the Egyptians are stated to have recorded 373 solar and 832 lunar eclipses; and he says this statement is probably true as the proportions are exact, and there should be the above number of each in from twelve hundred to thirteen hundred years.

—— The "Saturday Review" notices, as an instance of the reduction to absurdity of the conjectural method, the efforts of M. de Gubernatis to interpret the multiform stories of the cat and allusions to the cat in folk-lore, as parts of the great system of solar myths. With M. de Gubernatis, the cat with white ears in a fairy tale is the "morning twilight," or "the moon which chases the mice of night." A chattering cat appears in a Russian fairy story, and is killed in the territory of a hostile sultan. M. de Gubernatis explains that the sultan is "the wintry night," but leaves us in the dark as to what the chattering cat is. A cat is metamorphosed in a tale by Madame d'Aulnay into a woman who wears a dress of thin white gauze, set off with rose-colored taffeta, the gauze and rose-colored taffeta being inventions of the author's fancy which she has added to the

original story. M. de Gubernatis does not see them in this light, but regards them as something highly mythical, and as signifying that the white cat was the moon, and became the dawn. So in Æsop's fable of the cat-woman, that the bride went to bed must mean that "the evening aurora sinks into night." "The Italians describe an empty house by saying, 'There was not even a cat there.' But do they mean that the house is deserted, even by the home-loving, domestic puss? Nothing so commonplace. The proverb is derived from the sun entering the night, where he finds nothing, or 'only the cat moon.' Black cats are not black cats, but they are the moonless night. 'The cat in the bag of the proverb has probably a diabolical allusion!' When a German invalid sees two cats fight, he thinks it a bad omen. Why? Because, in M. de Gubernatis's opinion, the cats 'represent, perhaps, night and twilight.' It seems to be held that men take no interest in anything except so far as it may be considered a symbol of night or light. When *montes parturiunt*, and *nascitur ridiculus mus* (the mountains labor and a ridiculous mouse is born), the reference is not to the immensity of the labor and the minute results. Oh, no; 'from the mountain came forth the mice of night, the shadows of the night, to which the cat moon and cat twilight give chase.' . . . 'When the cat's away the mice will play.' What does this mean? It means that 'the shadows of night dance when the moon is absent,' which is precisely what they do not do. No moon, no shadows, still less any shadow-dance. The most ordinary truths of experience are not only set aside, but reversed, by the method of M. de Gubernatis, a method from which not even poor puss has escaped."

—— Baron von Nordenskiöld, in his "Voyage of the Vega," gives a pleasant account of the domestic life of the Chukches, the tribe that inhabits the northeasternmost part of Asia. "Within the family," he says, "the most remarkable unanimity prevails, so that we never heard a hard word exchanged, either between man and wife, parents and children, or between the married pair who own the tent and the unmarried who occasionally live in it. The power of the woman appears to be very great. In making the more important bargains, even about weapons and hunting implements, she is as a rule consulted, and her advice is taken. A number of things which form women's tools she can barter away on her own responsibility, or in any other way employ as she pleases. When the man has by barter procured a piece of cloth, tobacco, sugar, or such like, he generally hands it over to his wife to keep. The children are neither chastised nor scolded; they are, however, the best behaved I have ever seen. Their behavior in the tent is equal to that of the best brought-up European in the parlor. They are not, perhaps, so wild as ours, but are addicted to games which closely resemble those common among us in the country. Playthings are also in use, for instance dolls, bows, windmills with two sails, etc. If the parents get any delicacy they always give each of their children a bit, and there is never any quarrel as to the size of each child's portion. If a piece of sugar is given to one of the children in a crowd, it goes from mouth to mouth round the whole company. In the same way the child offers its father and mother a taste of the bit of sugar or piece of bread it has got. Even in childhood the Chukches are exceedingly patient. A girl who fell down from the ship's stair, head foremost, and thus got so violent a blow that she was almost deprived of hearing, scarcely uttered a cry. A boy, three or four years of age, much rolled up in furs, who fell down into a ditch cut in the ice on the ship's deck, and in consequence of his inconvenient dress could not get up, lay quietly still until he was observed and helped by one of the crew."

EDITOR'S TABLE.

DU BOIS-REYMOND ON EXERCISE.

MAGAZINES are of two kinds: the entertaining kind, which cater to mental laziness, and can be skimmed over without mental effort; and the instructive kind, which contain articles that must be read twice. "The Popular Science Monthly," from the start, has furnished a considerable proportion of articles so weighted with valuable thought as to require concentration of mind and often careful reperusal to grasp and assimilate their contents. This has provoked frequent protests on the part of our readers, who have complained that we deviate from the magazine-standard of easy reading, and are not true to our title, which promises a magazine adapted to the populace. Yes, but to the *improvement* of the populace! The "Monthly" was started for no other reason than because the standard of our current magazines was low—too low to reflect the best mental activity of the times. Their aim is to amuse and beguile their readers by calling forth the smallest possible amount of mental reaction. We started because the popular magazines, competing downward, shirked vigorous work, and were false to the demands of an age characterized beyond all others for its intellectual seriousness, and by the magnitude, importance, and practical quality of the questions that are occupying the ablest minds in all countries. These minds can not be followed—these questions can not be understood—without effort on the reader's part. This is the price that must be paid for real knowledge. People can not be amused into mental grasp and vigor, they must be *exercised* into it. We talk of mental progress, mental elevation, mental expansion, but these are attainable only on the condition of mental exertion.

We print, in two parts, another of those articles that have to be re-read to get their full import. It is by Professor Du Bois-Reymond, and is on "Exercise," so that it is at the same time an illustration and an exposition of our subject. It is a most original and instructive statement, and will well repay reperusal.

One of the inevitable effects of the advancement of science in various directions is the establishment of new connections of thought which are often most striking and significant. What can Darwinism have to do with exercise? Restricting the term Darwinism, as we must do, to natural selection, Du Bois-Reymond shows that they are very closely related. Viewing organic nature mechanically, the series of living beings has been unfolded during unlimited time by adaptation to new conditions, the course of movement being in an ascending scale. "From this point of view, organic nature appears not only as a machine, but also as a self-improving machine." But the law of self-improvement is, that powers and faculties are strengthened and grow by exercise, and are weakened by non-exercise. In the struggle for existence, therefore, those will win and survive in whom exercise has developed superior capacities and resources, while the less exercised and weaker fail and perish. The principle of exercise is thus a kind of motive-power in animal evolution, and, as might be expected, is full of the most important results in the higher spheres of physiological and psychical activity.

The predominance of pugilism and athletic sports, which depend upon "muscle," have favored the idea that the chief influence and benefit of exercise is upon the muscular system; but Professor Reymond shows that this is an error. An important effect is, of course, produced in the development of the muscles, which is very fully and interestingly traced out; but by far the most important and valuable influence of physical exercise is shown to be upon the nervous centers. "It is easy to show the error of the common view, and demonstrate that such bodily exercises as gymnastics, fencing, swimming, riding, dancing, and skating are much more exercises of the central nervous system, of the brain and spinal marrow. Every action of our body as a motive apparatus depends not less but more upon the proper co-operation of the muscles than upon the force of their contraction. In order to execute a composite motion, like a leap, the muscles must begin to work in the proper order, and the energy of each one of them must increase, halt, and diminish, according to a certain law, so that the result shall be the proper position of the limbs, and the proper velocity of the center of gravity in the proper direction."

But when it is established that the central nervous system is not only amenable to the law of exercise, but is the chief object of its influence, we then begin to see how the highest mental effects are involved in the question. Improvement by means of exercise and deterioration from non-exercise apply to the gray matter of the brain as well as to the muscles. From this point of view, which is that of the philosophy of human educability, the subject has a comprehensive interest, and we hope our readers will recognize that, in furnishing them articles that imply some effort in their mastery, we are conforming to the only law by which real mental improvement can be secured.

MORE SIGNS OF THE TIMES.

That there has been going forward within the last few years a rapid liberalization of public opinion on the subjects that are in issue between science and theology, everybody now admits; and, having done what little we could to promote this salutary result, we are naturally interested in all the striking indications of the growth of toleration in quarters where it has been previously but little looked for. We called attention a few months ago to the significance of a declaration made by an eminent English doctor of divinity that the appreciation of Herbert Spencer's system of philosophy is "an education to an age," and we have now to take note of another liberal concession of perhaps greater interest.

The Victoria Institute, a vigorous English society of nearly a thousand members, consisting chiefly of lords, bishops, and clergymen, was founded a few years ago for the broad purpose of reconciling orthodox Christianity with the revelations of science. It is a kind of British standing committee on the relations of science and theology, the duty of which is to consider and report on all the alleged cases of their conflict.

It has been long expected that the Institute would take up the question of the religious relations of Spencer's philosophy, and that has now been done. The last report of its proceedings, just published, contains an elaborate paper, attacking this system and claiming to demolish it, which was written by the Rev. W. D. Ground, and its reading was followed by an unusually full discussion of the subject by the members of the Institute. We have no room to reproduce at length either the essay or the comments that were made upon it; but there are certain features of both to which it seems desirable to call attention, because we here get weighty theological confirmation of positions that

have long been maintained in the Popular Science Monthly."

We have heard a great deal of Mr. Spencer's materialism. The charge has become stereotyped. It is said that this is a materialistic age; that life is materialistic; that science is materialistic, and that Spencer is the arch-materialist who works the doctrine up into a philosophy for universal gratification. We have always denied the truth of this accusation, and held that it has been made either in ignorance or dishonesty. We have maintained not only that Spencer is explicitly opposed to materialism, but that he has written with great power against it. And we have, moreover, maintained that, in the future emergencies of theological thought which are sure to result from the further progress of science, the value of Spencer's anti-materialistic logic will be better appreciated. All this has been regarded as sufficiently amusing, but how is it now with the experts of the Victoria Institute? The Rev. Mr. Ground says: "The existence and the immateriality of mind is a cardinal doctrine of Mr. Spencer's philosophy. It is one of the last and most certain deliverances of his philosophy that mind and matter both exist, and that between these two there is a chasm which no effort of ours enables us to cross. He exhausts the resources of language to declare that this is the one fact which transcends in absolute certainty every other fact. Somehow, this seems to have escaped the notice of many who have criticised his writings, and he is commonly believed to uphold something like materialism. Greater error, however, there can hardly be. Materialism has never before had such a powerful and uncompromising opponent, and it is hardly probable that it can ever again make head against his attacks. The doctrine of the absolute immateriality of mind is a structural part of his philosophy, and one which is simply invaluable to those who see the spiritual aspect of things."

In the discussion which followed the reading of the paper, there was not a word of protest against this statement. Various things were objected to, but this avowal, so directly in the teeth of current prejudice, provoked not the slightest criticism. It was, in fact, indorsed by the unanimous approval of Mr. Ground's argument, which was based upon the idea that Spencer is not a materialist, and derived its whole force from this assumption. Mr. Ground makes numerous citations from Spencer which incontestably prove his position; and this portion of his argument may be fairly put against the whole mass of criticism which aims to convict Spencer of materialism.

But there was one part of Mr. Ground's essay for which the society was not prepared: his estimate of the character of Spencer's work startled his audience. He began by saying: "The system of philosophy associated with the name of Herbert Spencer has now been nearly twenty years before the philosophical world, and it has slowly made its way until it has won a place in the first rank of such productions. Whatever we may think of it, it is not easy to withhold our intellectual homage. It is the last and probably the greatest attempt ever made to present a true philosophy of the kosmos; it is imbued with the modern scientific spirit; it claims to be strictly in accord with scientific principles; it displays a breadth of generalization and a wealth of energy such as we find only in the greatest works of all time; and it is by many believed to be one of the worthiest triumphs ever achieved by the unaided intellect of man. It is never easy to estimate justly any contemporary work—we stand too near it to see its true proportions—but it seems to not a few that Mr. Spencer may fairly claim a place in the front

rank of the intellect of the world. His greatness in this respect must in justice be conceded."

Mr. Ground in closing re-affirmed his high opinion of the import of Spencer's work as follows: "We may, however, allow that, if only he will keep within his proper limits, very much of what he has written will stand in lines of unfading truth and beauty, and he will have the honor of lifting the human intellect to a higher plane of thought and life. He is so great and many-sided, and he has contributed such a vast amount of intellectual force, that no one who reverences the mind of man as one of the greatest handiworks of God can honestly refuse him homage. He stands before us of the build of the giants, perhaps of the immortals, and his nature is not yet made up so as to show us what will be his ultimate place—whether amid those who shed kindly benefactions on the race, or those who like evil angels leave behind them a heritage of negation, unbelief, and despair."

Such talk was not at all palatable to the members of the Victoria Institute, who could not recognize much greatness in a man whom they had just seen so effectually "crushed." The chairman led by observing, "I would rather not have seen so very much admiration for Mr. Herbert Spencer combined with the reasoning of the paper, which proves so successfully that if this 'writer' is indeed a 'gia t,' he is but a giant stuffed with straw." The Rev. Dr. Irons remarked, "I concur fully with the chairman in saying that the estimate formed of Mr. Herbert Spencer was somewhat exaggerated, and yet I have to acknowledge the great admiration I entertain of Spencer's style and acuteness and power of analysis, and I do not think we gain anything by depreciating our opponents." Others followed in a similar strain, and only Professor Griffiths accepted the estimate of Spencer, and took exception to the general argument of the essay. In reviewing and closing the discussion, Mr. Ground admitted that he might have been over-impressed by Spencer's genius, but that it was very easy to commit the opposite mistake. He said: "I feel sure, however, that some in this Institute greatly underrate Mr. Spencer—a mistake which in my judgment would, if not corrected, bring disastrous consequences, but it is possible that I may have gone to the opposite extreme. In reading his philosophy, I am distinctly conscious that vaster thoughts are before me than when reading Shakespeare. Shakespeare one can take up any time as the companion of an idle hour, and the amount of mental stimulation he gives is relatively trifling. Not so is it with Spencer. It is only when the eye is keenest, the will strongest, the nervous force most abundant, that you can be sure of following him. The first (Shakespeare) carries you through the gentle undulations of an English county, and his highest elevations are hardly so much as Snowdon or Helvellyn, but Spencer carries you up the awful Alpine ranges, where the spaces of thought over which the eye roves are incomparably vaster, and where the exertion demanded is far greater. Spencer has a certain Miltonic grandeur. I could name places in his philosophy where views are given us of creation, in which, if we add the spiritual conceptions of which I spoke, the idea presented rises, to my mind, in extent, sublimity, and overpowering greatness above everything I have yet met with in all uninspired literature. To grasp his system is like standing in the Sistine Chapel and bearing the full weight of the conceptions of Michael Angelo. While this fact explains the fascination that Spencer exerts over many, it also shows us the great danger either of letting his system continue, as it no doubt is, the reigning philosophy of the world, or of depreciating it below its just value."

THE SLOW PROGRESS OF IDEAS.

In his recent excellent report to Columbia College, Dr. Barnard says, in discussing the policy of universities, "Newton stands perhaps without a peer in the scientific annals of all time, yet the astronomy of Ptolemy continued to be taught in Newton's own university of Cambridge for a century after the publication of the 'Principia' had created astronomical science anew." This is an excellent illustration of the power of habit and tradition in education. In further discussing "Education as a Science" in the same report, President Barnard quotes the following statement of the Rev. Mr. Quick, the Cambridge lecturer, on the history and philosophy of teaching: "I take it that Jacotot taught more emphatically than any one three great pedagogic truths: first, that a good teacher exercises the searching rather than the receiving faculties of the learner's mind; second, that all fresh knowledge should be connected with what the learner knew before; and, third, that a thorough knowledge of anything is an almost inexhaustible source of power. However, if his principles were right, there must have been some grave defect in the application of them, or his system, which at first met with immense success, would not so speedily have lost its ground." To this President Barnard adds, "The grave defect in the application consisted obviously in his pushing the first principle to an extravagant and unreasonable excess, and in leaving the pupil too entirely helpless."

We suspect that the reason why those golden truths of Jacotot have not been more generally accepted and practiced, and why his system perished with him, was deeper than is here indicated. Badly applied they no doubt were, but it is more significant that they were prematurely thoroughgoing, and involved the cutting up of an old system, root and branch. If it took a hundred years for the magnates of Cambridge University to recognize the demonstrated truths of the "Principia," how much longer will it take to introduce something like a law of gravitation into education? It is hurrying things if a great new principle gets well accepted in a century and intelligently applied in another century, and Jacotot's experiment is but half a century old. Science is making progress, but it moves precious slow in old educational establishments. Loading the memory with Greek and Latin seems still to be the leading business of Columbia College; while Dr. Barnard tells us that "zoology, botany, physiology, and biology are all unrepresented in our scheme of instruction." As a further illustration of the slowness of collegiate improvement and reform, it may be mentioned that, while Columbia College has a strong corps of teachers for drilling in the dead languages, it has no adequate provision for discipline in the correct and elegant use of the living language in which the intellectual life-work of all the students is to be carried on. Dr. Barnard laments that there is no sufficient provision "to practice the learner in the proper use of language," and urges the Board of Trustees to repair this and the other omissions referred to. From all of which we infer that, although knowledge goes slow, Columbia College goes slower.

Dr. Barnard desires to have the ladies patronize his institution, but they may well reply: "Not yet, dear doctor; you are too far behind the age. We appreciate the honor, and the society of the gentlemen would not be unpleasant; but it is a very important question whether the culture you are prepared to give us is the best calculated to qualify us for that sphere of life to which most of us are destined. We have all read that Agesilaus, King of Sparta, upon being asked what things he thought most proper for girls to learn, answered, 'Those which they

ought to practice when they come to be women.' Does your education answer to that test? Is a college in which physiology and biology are unrepresented, and which offers no instruction in anthropology—the science of human nature—the proper place to educate young women for the duties of motherhood, the nurture of children, and the intelligent practical administration of home affairs? We can not see that you have what we most want, and we are afraid if we came you would so fill our heads with everything we don't want that we should be worse off than if we were not educated at all. Go on with the excellent work of modernizing your curriculum, and, when you have made it to better represent the present state of knowledge, it will be time to talk to us about buying it."

This is encouraging. We had supposed that the ladies were crazy to get into the college anyhow, without the slightest regard to what they found there—in fact, wanted to get in merely because they had been kept out; accordingly, as this is not so, we rejoice.

COLLEGE GOVERNMENT.

We last year had the pleasure of commending the new departure of Amherst College in the matter of government. It consisted in an open repudiation of the old and still prevailing system of paternal control which so naturally engenders conflict and promotes excesses on the part of the students. As we before remarked, young men can only be educated in manhood by being practiced in its liberty and responsibility. The home government of childhood and early youth is necessarily paternal, watchful, care-taking, often too much so for the development of self-reliant character; but when boys become young men they have the right to substitute self-restraint for external restraint as the governing law of conduct. And especially when they go to college, where the scheme of studies assumes mental maturity, where the new social forces are so active, and the new temptations so strong, they should be thrown upon their honor, and pledged to self-control at the outset and without reserve. It is gratifying to observe that the second year's experience at Amherst proves the practicability and the superiority of the self-governing method. A correspondent of the "New York Evening Post" remarks:

> It has been a year of unusually satisfactory progress. Professor W. S. Tyler, who was graduated in 1830, and has been connected with the college ever since, says that it has been the most healthy and satisfactory year for the college that he has ever known. More and better work has been done in the studies, and there has never been a year of such perfect discipline. It is the new system of government, now at the end of its second year of practical working, which is given the credit of the improvement. In brief, the system is this: The relation of faculty and students is regarded as that of two parties to a contract. The student wishes to study, and contracts to follow the rules of the college. The faculty contract to give the instruction. If a student breaks his contract by disorderly conduct or by committing any of the irregular acts so common in colleges against public peace, he is held to have broken his contract, and *ipso facto* his connection with the college ceases. He has broken his word, and a rupture of the contract by one party releases the other. No vote of expulsion is passed. There is no writing home to parents. No member of the faculty is expected to act the spy. The single act of the student settles the whole thing. All this is now perfectly understood. When the system was introduced its first enforcement was particularly severe, and the students did not fully comprehend the situation. For that once only, after a full reparation for the wrong, the offenders were restored to their standing, and there has been no relaxation of the rule since. It was believed that the past year would be particularly trying, because the novelty would be worn off, and the permanent value of President Seelye's theory would be tested. Besides this change, there came with it a total abolition of the old ranking system, and so the test this year has been particularly severe. It is of high interest, therefore, that every one of the faculty, and, so far as is

known, every one of the students, is heartily in favor of the new system. Not a single disorder has occurred in college during the year. Even the freshmen, to burn their celebration bonfire, did not steal any one's fence, nor tear down any one's barn, but bought their materials and had an honest fire on the campus. A spirit of manliness and self-reliance has become prevalent to a degree which was utterly unknown when the students were under the parental system, and were inclined to regard the faculty as their natural enemies. About a fortnight ago the faculty made a thorough investigation into the scholarship in all departments, in order to compare the efficiency of the course now with what it was under the old method of discipline and working. It was found that the new way is better than the old by far, and that the scholarship of the students is better than formerly. This is not attributed to any higher average in the general ability of the young men, but solely to the stimulus which comes from the college atmosphere.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES, NO. XLII.

Ants, Bees, and Wasps. A Record of Observations on the Habits of the Social Hymenoptera. With Illustrations and Colored Plates. By Sir John Lubbock, Bart., M. P., F. R. S., etc. D. Appleton & Co. Pp. 448. Price, $2.

When, some ten years ago, the author of this work was solicited to contribute a volume to the "International Scientific Series," he cordially consented, on the condition that he might take his time. Nothing could be more reasonable, for Sir John is a very busy man, and occupied by many duties. But, now that his book has appeared, the surprise is that he should have done it so quickly. The most expeditious way of producing a book is, of course, with the scissors; the next is with the pen, where the work is spun from the fancy; but the slowest method is where the author strikes into original inquiry, which involves long-continued observation and experiment before he can bring the subject into shape for literary presentation. It is in this sense that Sir John Lubbock has *made* the present work. How it has originated, and what is its object, are thus stated in the preface: "This volume contains the record of various experiments made with ants, bees, and wasps, during the past ten years. Other occupations, and many interruptions, political and professional, have prevented me from making them as full and complete as I had hoped. My parliamentary duties in particular have absorbed most of my time just at the season of year when these insects can be most profitably studied. I have, therefore, whenever it seemed necessary, carefully recorded the month during which the observations were made, for the instincts and behavior of ants, bees, and wasps are by no means the same throughout the year. My object has been, not so much to describe the usual habits of these insects, as to test their mental conditions and powers of sense."

The work has, therefore, a twofold interest. In the first place, it is a contribution to comparative psychology; a subject which requires much more cautious and discriminating study than it has formerly received. The insects to which Sir John Lubbock has devoted himself exhibit remarkable mental traits, but it is by no means so easy a thing to interpret them rightly. Much, of course, was critically and accurately known of their habits and characters before our author took up the inquiry, as his copious bibliography and numerous citations show; but there was also so much loose and exaggerated statement in the popular natural history of these creatures, and so much serious deficiency in their scientific study, that a close and systematic re-examination of the phenomena was necessary. Sir John devised various ingenious methods of dealing with his insects, and by taking the ample time necessary to educate himself in their manipulation, and in getting familiarly acquainted with their ways, he has been enabled to qualify many previous opinions respecting their intelligence, and very much to extend our accurate knowledge upon the subject.

But while the problems which Sir John Lubbock had here to solve were those of comparative psychology, they have another interesting aspect. The insects being gregarious and eminently social, all their mental manifestations were in social relation, so that the inquiry ran inevitably into comparative sociology. It is this fact which gives

the highest interest to the research. It is of no little importance to find out how much these tiny creatures *know* which are capable of elaborating such curious and extensive social arrangements. Are they really next to man in the scale of intelligence? Sir John Lubbock seems to have arrived at this conclusion, but he opens his introductory chapter thus: "The anthropoid apes no doubt approach nearer to man in bodily structure than to any other animals; but when we consider the habits of ants, their social organization, their large communities, and elaborate habitations; their roadways, their possession of domestic animals, and even, in some cases, of slaves, it must be admitted that they have a fair claim to rank next to man in the scale of intelligence."

We have no space either to explain Sir John's interesting method of procedure in these researches, nor to intimate his results. But we may say that the author has thoroughly caught the spirit of his country neighbor, Mr. Darwin, and that his book is quite of the Darwinian order, evincing the most minute, painstaking, and patient observation, and reasoning no further or faster than the facts will warrant.

Capital and Population: A Study of the Economic Effects of their Relations to Each Other. By Frederick B. Hawley. New York: D. Appleton & Co. Pp. 267.

The author confesses his position, as exemplified in his treatise, to be a peculiar one. While considering himself a disciple of what is called the English and orthodox school in political economy, he has arrived at results which are in many instances diametrically opposed to those of that school; especially on the subjects of free trade and taxation. On the other hand, his reasoning presupposes the falsity of most of the arguments heretofore advanced in support of the very conclusions he upholds. These singular results are obtained by his taking up the reasonings of Mill and Ricardo, and others of their school, and carrying them out on their lines beyond the limits where they stopped, and by taking up and giving importance to factors that were unconsidered or overlooked by them. Having pointed out an important variation in the definition of capital as given by Ricardo and Mill, he makes the deduction that over-accumulation, or the increase of capital beyond the needs of population, is not only possible, but of frequent and periodic occurrence in all civilized nations; that there is, in fact, a tendency to it. He then undertakes to show that proportional and real wages vary inversely instead of together, as has heretofore been assumed, and that it is not a high rate of proportional wages, but of real wages, that is a stimulus to population. He further reaches conclusions opposed to free trade and in favor of the protective policy; that manufactures are more advantageous as a national pursuit than agriculture, and commerce is more advantageous than either; and finds a basis for a positive decision in favor of bi-metallism.

John Stuart Mill. A Criticism, with Personal Recollections. By Alexander Bain, LL. D. Henry Holt & Co. Pp. 201. Price, $1.25.

This volume is precisely what was needed to supplement Mill's "Autobiography." While, on the one hand, that work is invaluable as a disclosure of personality, and as an interpreter of mental experience, such as none but the author himself could give, on the other hand it is full of the necessary bias and the limitations of an auto-representation, and contains defects and omissions which only another mind could supply. Dr. Bain was pre-eminently the man to add this counterpart to Mill's own sketch of his life. He knew the man intimately, was himself an independent student of the whole range of questions to which Mill devoted himself, while the two men were in such sympathy that Mr. Mill intrusted to Professor Bain the revision of the proof-sheets of the "Logic," his greatest and most important work. With such a preparation, Professor Bain could not fail to give us a most interesting sketch, and which is at the same time a critical estimate of Mill's publications. Much light is thrown on the circumstances of the production of each work—how the author was led to the subject, how his views were modified or expanded, and how he was influenced by the leading contemporary minds of his time. There is an interesting analysis of Mill's relation to Comte, and a still more inter-

esting statement of his relations with Mrs. John Taylor, whom, after twenty years' acquaintance as a married woman, after the death of her husband, Mill married. There is a critical examination of his extravagant claims in regard to the talent of this lady, and also of Mill's attitude toward the "woman question" generally.

There are various important points, on which Dr. Bain disagrees with Mill, which we should like to have seen further elucidated, and to a consideration of some of these we may return in future. But the points of objection are generally well taken. We are gratified to observe that Dr. Bain holds exactly the opinion which we have maintained in regard to Mill's celebrated "University Address" on education. As the questions involved are of permanent interest, it may be well to quote what Bain says about this performance of Mill:

> The St. Andrews address was a very lengthened performance; its delivery lasted three hours. It aimed at a complete survey of the higher education. Its absolute value is considerable; but, in relation to the time, place, and circumstances, I consider it to have been a mistake. Mill had taken it into his head that the Greek and Roman classics had been too hardly pressed by the votaries of science, and were in some danger of being excluded from the higher teaching; and he occupies nearly half of the address in vindicating their importance. The second half is a vigorous enforcement of the claims of science.
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> The performance was a failure, in my opinion, for this simple reason, that he had no conception of the limits of a university curriculum. The Scotch universities have been distinguished for the amount of study comprised in their arts degree. Mill would have them keep up the classics intact, and even raise their standard; he would also include a complete course of the primary sciences—mathematics, physics, chemistry, physiology, logic, and psychology—to which he would add political economy, jurisprudence, and international law. Now at present the obligatory sciences are mathematics, natural philosophy, logic, and moral philosophy. If he had consulted me on this occasion, I should have endeavored to impress upon him the limits of our possible curriculum, and should have asked him to arbitrate between the claims of literature and science, so as to make the very most of our time and means. He would then have had to balance Latin and Greek against chemistry, physiology, and jurisprudence; for it is quite certain that both these languages would have to be dropped absolutely, to admit his extended science course. In that case he would have been more careful in his statements as to the Greek and Latin languages. He would not have put these languages as synonymous with "literature"; and he would have made much more allowance for translations and expositions through the modern languages. He would have found that at the present day we have other methods of correcting the tendency to mistake words for things than learning any two or three additional languages. He would not have assumed that our pupils are made all "to think in Greek"; nor would he have considered it impossible to get at the sources of Greek and Roman history without studying the languages. If he had a real opponent, he would not have given the authority of his name to the assertion that grammar is "elementary logic." His mode of speaking of the style of the ancient writers, to my mind at least, is greatly exaggerated. "Look at an oration of Demosthenes; there is nothing in it which calls attention to itself as style at all. . . . The Athenians do not cry out, What a splendid speaker, but, Let us march against Philip." He also gives way to the common remark that the teaching of Latin and Greek could be so much improved as to make it an inconsiderable draft upon a pupil's energies. On this point he had no experience to go upon but his own, and that did not support his position.
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> In the scientific departments he carries out strictly the Comte hierarchy of the fundamental sciences, and, in this respect, the address was valuable as against the mischievous practice of culling out a science from the middle of the series, say chemistry, and prescribing it by itself to the exclusion of its forerunners in the hierarchy. While he speaks fairly and well on the mathematical and physical sciences, his remarks on the moral and political display, as usual, the master's hand. He next goes on to talk of free thought, on which he maintains a somewhat impracticable ideal for our universities. From science he proceeds to art, and enforces a favorite theme—the subservience of poetry to virtue and morality. One feels that on this topic a little more discrimination was necessary; art being a very wide word. His conclusion was a *double entendre*: "I do not attempt to instigate you by the prospect of direct rewards, either earthly or heavenly; the less we think about being rewarded in either way, the better for us."
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> In the reception given to the address, he was most struck with the vociferous applause of the divinity students at the free-thought passage. He was privately thanked by others among the hearers for this part.

THE MEDICAL ADVISER IN LIFE ASSURANCE. By EDWARD HENRY SIEVEKING, M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 206. Price, $2.

THE author's object is to furnish the reader with information which, if it is to be found at all in the ordinary works of medicine, is so scattered as not to be readily

available. Much of the substance of the book is derived from the experience of the author, or has been placed at his disposal by friends who have been engaged in the study of questions connected with life insurance. The special topics of "The Normal Man," "The Duties of the Medical Officer," "Hereditary Influences," "The History of the Individual," "The Insuree's Liability to Disease," and "The Medico-Legal Aspects of Life Insurance," are considered.

Geological Survey of New Jersey. Annual Report of the State Geologist for the Year 1881. Trenton, New Jersey: John L. Murphy. Pp. 308, with Map and Table of Temperatures.

The topographical survey has been pushed, during the year, westward across Morris County and the central part of Warren County, to the Delaware River at Belvidere, the work covering an area of 360 square miles, and making, with what had been previously done, a total area of about 1,260 square miles completed. In the several chapters of the report are considered the encroachments of the sea upon the low-lying lands of the shore, the ores of iron and other metals, and quarries of stone in the State, with statistics; and more than half of the volume is occupied with the consideration of "the climate of New Jersey." An excellent geological map of the State accompanies the report.

From River to Sea. A Tourists' and Miners' Guide from the Missouri River to the Pacific Ocean, *via* Kansas, Colorado, New Mexico, Arizona, and California. Charles S. Gleed, Editor. Chicago: Rand, McNally & Co. Pp. 240. Price, $1.

This work is designed to supply a want. Its purpose is to give people a good general idea of the vast territory which is tributary to the new line of railway communication (Atchison, Topeka and Santa Fé Railway) between the Missouri River and the Pacific Ocean. It embodies a great deal of information of a kind which the traveler looks for, and will be generally useful to him. The illustrations, which are fairly well but not finely executed, lose a large part of their value by being inserted without reference to the text, and in a not regular order.

Political Institutions: Being Part V of the Principles of Sociology. The Concluding Portion of Volume II. By Herbert Spencer. Pp. 457. Price, $1.50.

The second volume of Spencer's "Principles of Sociology" is devoted to the evolution of I, Ceremonial Institutions, and II, Political Institutions; and, as the first part was issued separately about two years ago, the second part is now also issued separately, for the convenience of those who have procured the other.

Although this work is in its nature historical, yet it is necessary to discriminate between the method of ordinary history and that here adopted. Common history only applies to the later stages of progress, and it would deal with political institutions only in their higher modifications. But the idea of "development" implies that of origin, and carries us back to prehistoric times and primitive conditions. The question is, in what way the earlier or rudimentary forms of political institutions grew up. This problem lies back of that of the ordinary historian, is of a deeper nature, and can only be successfully pursued under the guidance of some general theory of social genesis which will throw a common light on the development of ceremonial, political, ecclesiastical, and industrial institutions. Such a theory is that of evolution, and accordingly it is here made a part of the exposition of that theory. Of the difficulties of the exposition growing out of the nature of the subject, and the imperfections due to its subordination to a larger scheme of thought, the author says:

> The division of the "Principles of Sociology" herewith issued, deals with phenomena of Evolution which are, above all others, obscure and entangled. To discover what truths may be affirmed of political organizations at large is a task beset by difficulties that are at once many and great—difficulties arising from unlikeness of the various human races, from differences among the modes of life entailed by circumstances on the societies formed of them, from the numerous contrasts of sizes and degrees of culture exhibited by such societies, from their perpetual interferences with one another's processes of evolution by means of wars, and from accompanying breakings-up and aggregations in ever-changing ways.
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> Satisfactory achievement of this task would require the labors of a life. Having been able to devote to it but two years, I feel that the re-

sults set forth in this volume must of necessity be full of imperfections. If it be asked why, being thus conscious that far more time and wider investigation are requisite for the proper treatment of a subject so immense and involved, I have undertaken it, my reply is that I have been obliged to deal with political evolution as a part of the general Theory of Evolution; and, with due regard to the claims of other parts, could not make a more prolonged preparation. Any one who undertakes to trace the general laws of transformation which hold throughout all orders of phenomena must have but an incomplete knowledge of each order; since, to acquaint himself exhaustively with any one order, demanding, as it would, exclusive devotion of his days to it, would negative like devotion to any of the others, and much more would negative generalization of the whole. Either generalization of the whole ought never to be attempted, or, if it is attempted, it must be by one who gives to each part such time only as is requisite to master the cardinal truths it presents. Believing that generalization of the whole is supremely important, and that no one part can be fully understood without it, I have ventured to treat of Political Institutions after the manner implied: utilizing, for the purpose, the materials which, in the space of fourteen years, have been gathered together in the "Descriptive Sociology," and joining with them such further materials as, during the last two years, have been accumulated by inquiries in other directions, made personally and by proxy.

Statistics of the Production of the Precious Metals in the United States. By Clarence King, Special Agent of the Census. Washington: Government Printing-Office. Pp. 94, with Six Plates.

The information on which this report is based has been procured, so far as is possible, directly from the producers of bullion. It was not expected that completeness could be reached in this way, for many small producers would be overlooked or would fail to report, but the plan gives a nearer approach to accuracy than can be gained from the comparison of the receipts of domestic bullion at the mints and assay-offices, or from an examination of the bullion accounts of the express companies—the only other sources of information that were open. A comparison of the annual output of different States shows that the United States produces 33·13 per cent of the gold yield of the whole world, 50·59 per cent of the silver, and 40·91 per cent of the total. Of the aggregate supply of the precious metals, North America furnishes 55·78 per cent.

Hand-Book of Invertebrate Zoölogy for Laboratories and Seaside Work. By W. H. Brooks, Ph. D. Boston: S. E. Cassino. Pp. 392, 200 Cuts. Price, $3.

This volume has very strong claims upon the biological student; but for the beginner, especially if he lives near the sea, it is incomparable. The art of starting a beginner aright in any branch has not yet been perfected, but Dr. Brooks has made a successful stroke in this direction for zoölogical science. The work has been planned with reference to the exigencies of systematic study, and to put the student upon the right track to attain the mastery of the subject with the least waste of exertion. Nothing is introduced that is not wanted. Generalizations and comparisons are omitted, on the principle that the beginner shall first get at the facts, in order that he may subsequently grasp and make the generalizations his own. The work is therefore not a text-book, but a hand-book of practical study, and is admirably adapted for self-instruction. In his prefatory remarks describing the work, the author says: "Most lecturers upon natural science find, no doubt, that preliminary work, the presentation of facts upon which science is based, absorbs so much time that there is no room for a philosophical discussion of the scientific aspects of the subject. I have therefore attempted to show the student how to acquire a knowledge of the facts for himself, in order to remove this burden from lecturers and text-books."

The types selected for description are, of course, but few compared with those considered in systematic works; but still they cover wide zoölogical ground, and are sufficient to prepare for more comprehensive research. In the treatment of each type the author has not attempted to present all that is known about it, but simply to guide the beginner to those features which he can find and observe for himself. And so also with the illustrations. The minute details of complicated structural figures are omitted, and only those given that it is necessary for the beginner himself to discover in his examination of the specimens. For this purpose, the illustrations are greatly superior to any we have elsewhere seen.

The book begins with the examination

of amœbæ, and the opening directions for obtaining them will give a good idea of the clearness, directness, and simplicity with which the whole work is written:

> Amœbæ are frequently to be found in abundance in the superficial ooze which forms a thin layer upon the bottom of nearly every quiet body of fresh water. The ooze may be collected from a pond, stream, or ditch, by gently and slowly skimming the bottom with a tin dipper fastened to a long handle. In gathering the ooze be careful to barely skim the surface, and to avoid disturbing the black mud which usually occurs just below the ooze.
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> Transfer the material thus gathered to a collecting-bottle, and gather ooze from several bodies of water, preserving each specimen in a separate bottle, for amœbæ may be abundant in one locality and almost absent in another. Pour the ooze into shallow dishes, such as soup-plates or baking-dishes, putting enough into each dish to form a layer about an eighth of an inch deep over the bottom.
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> Place the dishes near the window, where they will be well lighted without exposure to the direct rays of the sun; fill them with fresh water, and allow them to stand undisturbed for two or three days, in order to allow the amœbæ to creep out of the ooze and accumulate at its surface.
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> If a permanent supply of amœbæ is desired, each dish may be converted into a small aquarium by the addition of a few floating water-plants, such as "duck-weed," and when covered with a pane of glass, to exclude dust and prevent excessive evaporation, may be kept in good order for several months by simply replacing with fresh water the loss by evaporation.
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> In a day or two a thin brownish-yellow film will usually be visible over the whole or parts of the surface of the ooze; and portions of this film, almost entirely made up of microscopic organisms which have crept to the surface, may now be examined for amœbæ, in the following manner.

It only remains to add that this work is published at a very low price. Considering its cost and elegance, we hardly know of another so cheap a book. And, considering that there is no other book at all like it to serve the purposes of introductory study in its field, it ought to be in wide demand by the students of natural history.

Essays on the Floating Matter of the Air, in Relation to Putrefaction and Infection. With Illustrations. By John Tyndall, F. R. S., M. D. D. Appleton & Co. Pp. 338. Price, $1.50.

Some of the researches contained in this book have appeared in the pages of "The Popular Science Monthly," and nothing, therefore, need be said to our readers that is merely commendatory of their interest. The volume is the result of extended researches into one of the obscurest of subjects—the nature, conditions, and influence of the invisible microscopic life of the atmosphere. Any inquiry into the dust and floating contents of the air, if thoroughly pursued, leads to the more subtile question of infinitesimal forms of life and their germs as floating elements of the breathing medium. Profound problems are here encountered: Are these germs spontaneously originated, or are they subject to the laws of propagation which govern all other grades of life? Again, are these germs the seeds of disease which affect the higher forms of life, and thus become of the highest moment to the physician and the hygienist? The import of the subject has been disclosed only within the last few years, and depends upon the perfection of the microscope, and the most refined researches into the nature and effects of fermentation and putrefaction. Many able men in different countries have been working, with intense assiduity, over different branches of this momentous inquiry; but it was on many accounts fortunate that Professor Tyndall, about a dozen years ago, saw its importance, and brought all his resources to bear upon its systematic investigation. That he has thrown much more light upon the subject by his skillful and extensive experiments, and that he has made very important contributions to the establishment of the germ theory of disease, will not be questioned. But in still another respect it is fortunate that he identified himself with its elucidation. By his rare power of exposition, and his wonderful clearness of statement, he has done more, perhaps, than all other writers to impress the medical profession and the public both with the vital importance of the subject and the advance that has been made in the establishment of its fundamental principles. His present book embodies the main results of his original work, and, what is more, it presents them in so lucid and inviting a form that all classes of readers will be equally pleased and instructed by his views.

There is, perhaps, in the whole field of science no illustration more striking than is here afforded of the fruitful practical

application of investigations undertaken for the simple purpose of the extension of knowledge, with no perception of its ultimate utilities. While one division of laborers, spurred by the urgent necessities of observers, spent their energies in bringing the microscope up to its highest power, another division was equally absorbed in finding out what could be known of the newly revealed world of microscopic life. The stimulus of the love of discovery was sufficient to insure the successful progress of both. But now we begin to see the beneficent ripening of their results as they could not see it. As a legitimate issue of those labors, we have arrived at views of the nature and propagation of diseases that will make an epoch in the advance of medical and hygienic science. We print, in the present Monthly, the Introductory Note to Professor Tyndall's volume, which is very instructive in regard to the present position and future influence of the "Germ Theory of Disease."

A Dictionary of Music and Musicians (a. d. 1450–1881). By Eminent Writers, English and Foreign. Edited by George Grove, D. C. L. Part XIV. London and New York: Macmillan & Co. Pp. 128. Price, $1.

The present number includes the titles from Richter to Schorberlechner. The plan and execution of the work are commendable. The information is given in well-written and easily readable articles, the length of which is adapted to the character and importance of the subject. Biographies of eminent composers, performers, instrument-makers, and other musical persons, predominate in the present number, ranging from few-line notices of little distinguished instrumentalists to the sixteen-page article that is given to a distinguished composer like Rossini. Besides these, the number before us has paragraphs, within a few pages, on such subjects as "Ridotto," the opera of Rienzi, "Rigadoon," with a musical passage to show what it is, the opera of Rinaldo, "Rinforzando," "Ripieno," "Ritardando" and its synonyms, "Ritornello" with other musical illustrations, etc. We mention these heads to give only an inadequate idea of the abundance and variety of the material with which the work deals.

Our Homes. By Henry Hartshorne, A. M., M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 150. Price, 50 cents.

A volume in the series of "American Health Primers," edited by Dr. W. W. Keen. It is a practical, pleasant-reading treatise on house-building, house management, and house sanitation, considering the subject under the heads of situation, construction, light, warmth, ventilation, water-supply, drainage, disinfection, population (the relations of density of population to health), and working-men's homes.

The Wine Question in the Light of the New Dispensation. By John Ellis, M. D. New York: Published by the author. Pp. 228.

The controversy respecting the use of fermented or unfermented wine in the communion service is considered here in the light of the teaching of the Swedenborgian Church, with citations from authorities and opinions outside of that church, all going to sustain the presumption that unfermented wine is the kind to be used.

The Rhymester; or, the Rules of Rhyme. A Guide to English Versification. By the late Tom Hood. Edited, with Additions, by Arthur Penn. New York: D. Appleton & Co. Pp. 208. Price, $1.

The author believes that verse-making—not trying to write poetry—is of use as an exercise for fixing accurate pronunciation; and that, if done at all, it should be well done. He accordingly gives here the rules for doing it well. Many changes have been made by the American editor, of which the more material ones are marked, and chapters have been added on the sonnet, the rondeau, and the ballade, and on the other fixed forms of verse.

The Books of All Time. A Guide for the Purchase of Books. Compiled by F. Leypoldt and Lynds E. Jones. New York: F. Leypoldt. Pp. 80.

A list of approved books is given, with the prices of the best or most popular editions; and to each title are attached bits of criticism which throw some light on the characteristics of the author. The list, as a whole, is a good one and deserves approval, but would have been better for a little closer pruning away of mediocre books.

A Reading Diary of Modern Fiction. Containing a Representative List of the Novels of the Nineteenth Century, preceded by Suggestive Remarks on Novels and Novel-reading. New York: F. Leypoldt. Pp. 150.

The main object of this work is stated to be "to present a survey of all that is considered worth reading in the domain of modern fiction, and thus to make easy a daily record of what has been read and what to read next, with a view to comparing notes and a mutual exchange of recommendations among congenial friends." For this purpose a column in each page is given of "Books worth Reading," and is followed by blank columns for estimating merit, and recording other books that may be suggested. Our remark is, that the catalogue is too full. We should not like any one for whose mental cultivation we cared to become acquainted with so many novels. If the list were only one tenth as large, it would be many times more valuable.

The Practice of Commercial Organic Analysis. By Alfred H. Allen, F. I. C., F. C. S., Lecturer on Chemistry and Public Analyst. Volume II, Hydro-carbons, Fixed Oils and Fats, Sugars, Starch, Alkaloids, and Organic Bases, etc. Philadelphia: Presley Blakiston. 1882. 8vo. Pp. 561. Price, $5.

To those chemists who are already the fortunate possessors of the first volume of Mr. Allen's work, it will be good news to know that the second volume has at last been issued, for its appearance has been awaited with some impatience. In the former volume we had a full description of the alcohols, with the acids and ethers derived from them; also the phenols, carbolic, salicylic, and benzoic acids, as well as all the cyanogen bodies. The present volume, which is much larger than the former, contains the new methods of analysis of many articles of present interest. The analytical chemist will probably turn first to the chapter on glucose and grape-sugar, for on these subjects reliable and practicable information is meager. Here, for the first time, we believe, methods for estimating maltose are given, and attention is called to the error which it causes when Fehling's solution is employed for the estimation of dextrose in commercial glucose. The method of determining dextrose, maltose, and dextrine in the same solution from the rotatory and reducing power, in connection with the specific gravity of the solution, is clearly and concisely given.

Next in interest to glucose is the analysis of butter, and, although the chemist has not yet attained perfection in this, we find here the best methods known at present for detecting oleomargarine. The last chapter, a lengthy one, is devoted to aniline derivatives, the assay of aniline dyes, the identification of coal-tar colors, and the recognition of dyes on tissues.

We bespeak for the book the most favorable attention, because it is the *only* complete work on this subject in the English language, because it is new and up to the times, and because its author is well known as a practical analyst. The work is indispensable to the laboratory.

Currency; or, The Fundamental Principles of Monetary Science postulated, explained, and applied. By Hugh Bowlby Willson. New York: G. P. Putnam's Sons. Pp. 309. Price, $1.50.

The author contemplated, when he began, many years ago, his investigations on the subject of this work, writing a synopsis of the theories and practices of ancient and modern nations in respect to their currencies, but soon discovered that he would not have time to perform the task. The present work, the scope of which is more limited, has grown out of a series of postulates which he published in 1875–'76, in a London journal, for the purpose of directing attention to the desirability of embodying the ascertained and generally accepted principles of monetary science in a few "simple if not self-evident" propositions. Professor Bonamy Price, of Oxford, wrote him a note of thanks for his letter, saying, "It is exceedingly good, and I rejoice over it much, especially the postulates and principles." Much space is devoted to attacking the "prejudices and ignorance" which uphold the present systems of issuing and supplying paper money, they containing much that is regarded as at variance with scientific principles. The plan of delegating the issue of paper money to banking corporations other than the government is assailed; and

the result of the author's deductions "has been the evolvement of a purely automatic method of supplying both coined and paper money," with supply and demand as the only motive power to be used in keeping the automaton in motion. In opposition to the "mercantile theory," which seeks to accumulate the largest stores of the precious metals in a country, a plan is contended for which leaves those metals "free to the distribution of the natural forces of industry and trade."

History of the Water-Supply of the World. Arranged in a Comprehensive Form from Eminent Authorities. By Thomas J. Bell, Assistant Superintendent of the Cincinnati Water-Works. Cincinnati: Peter G. Thomson. Pp. 134. Price (paper), 50 cents.

The original intention of this work was to arrange a compilation of general and local information on the subject of water-supply in all of its bearings, with special reference to Cincinnati, and to the project for a new supply for that city. As the work progressed, its scope became broader, and the plan assumed a more comprehensive form. The work contains a description of the various methods of water-supply, and discusses the pollution and purification of water, sanitary effects, and analyses of potable waters; and, further, considers other topics having special reference to Cincinnati, the Ohio River, and the proposed water-supply of the city.

A Compendious Dictionary of the French Language. Adapted from the Dictionaries of Professor Alfred Edwall. By Gustave Masson. New York: Macmillan & Co. Pp. 416. Price, $1.

A most excellent dictionary for daily use. The compiler has endeavored especially to realize the qualities of accuracy and completeness, and to keep equally distant from exaggerated concision and overabundance of detail. The letter-press is clear, yet compact. The matter is arranged in four columns to the page, the words are printed in bold-face type to catch the eye readily, and the definitions are satisfactorily full. Particular attention has been paid to etymologies in the French-English part. A supplement, giving the principal diverging derivatives or doublets in the language (showing how words have varied from the Latin roots and from the congeners in other Romance languages) is of much use and interest to students. The Chronological Tables of the History of French Literature from the earliest period to the present day, of chronicles and memoirs, and the other literary information with which the work is introduced, will be welcome to many who would otherwise find it difficult to obtain, from the numerous sources from which it would have to be drawn, the information which they convey.

How the Great Prevailing Winds and Ocean-Currents are produced, and how they affect the Temperature and Dimensity of Lands and Seas. By C. A. M. Taber. Boston: A. Williams & Co. Pp. 82. Price, 40 cents.

The author states as a reason for this publication that, after many years of experience on the oceans, he has found that the generally accepted theories of the causes of the great winds and currents were not in harmony with the world-wide operations of nature, but were rather adapted to certain areas of oceans and continents than applicable to larger portions of the globe, "where the great movements of the atmosphere and ocean are not concordant with the generally accepted explanations." He reviews the theories of Hadley, Maury, Adhemar, Croll, Geikie, and other authors who have written upon the subject, shows wherein he regards them as deficient, and elaborates his own theory, in which a depression of sea-level on the western, and elevation on the eastern sides of the ocean, by the force of the west winds, and an independent circulation of waters around the poles, form important parts.

Primary Helps: Being No. 1 of a New Series of Kindergarten Manuals. By W. N. Hailmann, A. M., editor of "The Kindergarten Messenger and the New Education." Syracuse, New York: C. W. Bardeen. Pp. 29, with Fifteen Plates. Price, 75 cents.

Professor Hailmann is an enthusiastic Kindergartner, a practical teacher, and a member of the Board of Education of Detroit, Michigan. It has been his aim for years to bring those engaged in the Kindergarten work into harmony, and especially to

establish a connection between the Kindergarten and the public schools. The present book is the first fruits of his efforts in this direction, and aims to make the principles of Froebel applicable to primary schools.

Report on the Geology of the Henry Mountains. By G. K. Gilbert. Washington: Government Printing-Office. Pp. 170, with full-page Engravings and Photographs.

The author expresses a considerable degree of satisfaction at the manner in which his work in the survey of these mountains has been accomplished. He had his own way in conducting it, and pursued it under circumstances of exceptional advantage, with the result that, he says, "so thorough was the display [of the formations], and so satisfactory the examination, that, in preparing my report, I have felt less than ever before the desire to revisit the field and prove my conclusions by more extended observation." The Henry Mountains are not a range, and have no trend, but are simply a group of five individual mountains, separated by low passes, and without discernible system of arrangement, situated in Southern Utah, on the right bank of the Colorado River of the West, and between its tributaries, the Fremont and the Escalente. The highest peaks rise about 5,000 feet above the plateau at their base, and 11,000 feet above the level of the ocean. At the time of their discovery by Professor Powell they were in the center of the largest unexplored district in the United States; and they are in a desert country that has hardly any economic value.

A Bibliography of Fossil Insects. By Samuel H. Scudder. Pp. 48.

This work forms one of the series of the "Catalogue of the Library of Harvard University," and is one of the first formal attempts to collect separately the titles of papers on fossil insects. It shows the results of great labor, for it gives not only the titles of books and papers on the subject, but also a very large number of references to works and essays in which fossil insects are only referred to, or form one among other topics of equal prominence, which are touched upon in the course of a chapter, essay, or book, and in all the principal languages of science. Except when otherwise stated, all the papers quoted have been examined by the author personally.

Tables for the Determination, Description, and Classification of Minerals. By James C. Foye, Ph. D., Professor in Lawrence University. Chicago: Jansen, McClurg & Co. Pp. 85. Price, $1.

The object of this work is to furnish tables by means of which students may, with as few easy tests as possible, learn to determine and classify minerals found in the United States, and become familiar with their principal characteristics. Two tables serve for the determination of species; a third gives the crystalline structure and other distinctive characteristics of each species; a fourth classifies the species according to "Dana's Mineralogy"; and a fifth classifies by basic elements and ores. The appendix gives the distinctions between some of the closely allied species and varieties. A great deal of information is compressed into a small space.

PUBLICATIONS RECEIVED.

The Little Mountains East of the Catskills. By W. M. Davis. Pp. 33. With Plate.

Scientific Proceedings of the Ohio Mechanics' Institute. Vol. I. No. 2. Cincinnati, May, 1882. Pp. 50.

Clinical Contributions to Electrical Therapeutics. By Romaine J. Curtiss, M. D. Joliet, Illinois. Pp. 52.

Quarterly Report of the Bureau of Statistics for Three Months ended March 31, 1882. Washington: Government Printing-Office. Pp. 96.

Note on the Aurora of April 16-17, 1882. By H. Carvill Lewis. Pp. 9. Illustrated.

Proceedings of the National Association for the Protection of the Insane and the Prevention of Insanity. New York: G. P. Putnam's Sons. 1882. Pp. 55.

Missouri Historical Society. Publication No. 6. Archæology of Missouri. By F. H. Hilder. St. Louis, Missouri. Pp. 17.

A New Theory of the Suspension System, with Stiffening Truss. By A. Jay DuBois, Ph. D. Pp. 43.

Indian Languages of the Pacific States and Territories, and of the Pueblos of New Mexico. By Albert S. Gatschet. New York: A. S. Barnes & Co. 1882. Pp. 10.

Preventing Disease. By J. R. Black, M. D. Newark, Ohio. Pp. 17.

Charles Robert Darwin. By Joseph F. James. Read before the Cincinnati Society of Natural History, May 2, 1882. Pp. 7.

A Bill regulating Rates of Postage. Boston: Alfred Mudge & Son, Printers. 1882. Pp. 9.

The Student's Guide in Quantitative Analysis. By H. Carrington Bolton, Ph. D. Illustrated. New York: John Wiley & Sons. 1882. Pp. 127. $1.50.

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POPULAR MISCELLANY.

The Great Telescope at Princeton.—The new telescope for the Halsted Observatory at Princeton has been mounted within the past few weeks, and is now ready for work. In magnitude it ranks at present as fourth among the great refracting telescopes of the world, and second in the United States. Its only superiors in size are the Vienna refractor, of twenty-seven inches diameter, the telescope of the Naval Observatory at Washington, twenty-six inches in diameter, and the telescope of Mr. Newhall, at Newcastle, in England, which has an aperture of twenty-five inches. A number of still larger instruments are indeed under construction, but it will be some time before any of them are actually in place. The object-glass of the Princeton telescope is twenty-three inches in diameter, and has a focal length of thirty feet. The glass disks were cast by Feil, in Paris, but the telescope was made by Alvan Clark & Sons, of Cambridge. Though the telescope is a little smaller than the Washington equatorial, its mounting is considerably heavier and firmer, and is improved in many respects. The regulator of the driving-clock is unusually powerful, and, to prevent friction and wear of its pivots, its shaft is floated in mercury. The clamps and slow-motions are all managed without removing the eye from the eye-piece, and the declination circle is also read from the eye-end by a new and ingenious arrangement of the makers. The object-glass is peculiar in having its two lenses separated by a space of about seven inches, so as to allow a free circulation of air between them, thus greatly diminishing the disturbing effect of changes of temperature. This construction secures also freedom from the "ghosts" (formed by reflection between the lenses) which are so troublesome in many large instruments. The curves of the lenses are not those usually employed, but are somewhat like those of the Gaussian system, though not so deep. The color and spherical aberration are very perfectly corrected, and the performance of the glass, so far as can be judged from a few nights' work, is extremely fine. The instrument is, of course, provided with all the usual micrometers, eye-pieces, and other accessories, but as its chief occupation, for the present at least, is to be in the line of stellar spectroscopy, special attention has been given to the spectroscope, which is the most powerful ever made for star-work. It is a direct-vision instrument, on the plan of that used for some years back at Greenwich, though much larger. It was constructed by Hilger, of London, under the kind supervision of Mr. Christie (the present Astronomer Royal), in accordance with his own designs. It has

three of his so-called half-prisms, of such size as to take a beam two and one quarter inches in diameter, and is nearly six feet long. The whole cost of the telescope and spectroscope was $26,000, which was provided by the generosity of Robert Bonner, R. L. Stuart, and other friends of science and the college. The observatory itself, of which the corner-stone was laid sixteen years ago, has been newly fitted up for its occupant. A gas-engine furnishes the power for moving the dome and working the shutters, and it also drives an Edison dynamo electric machine which provides a powerful current to be used for lighting purposes, or to supply the spectra of gases and metals to be compared with the spectra of the stars.

American Archæological Researches.—The third annual report of the Archæological Institute of America reviews the work that has been pursued by the agents of the institute in archæological explorations in New Mexico and Mexico, and in the excavations at the ancient Greek city of Assos, and includes the first report of the committee on the American school of classical studies at Athens. Mr. Bandelier, who had been exploring in New Mexico in the service of the institute, spent some time in Mexico, first at Cholula, where he studied the history of the city and the manners and customs, the habits and superstitions, and the domestic architecture of the present native Indian inhabitants. He inquired into the origin and character of the ancient Mexican deity Quetzal-Chohuatl, and the significance of the myth attached to his name, and made a study of the great pyramid of Cholula. The latter, he declares, is not entitled to be called a pyramid, but is only a huge mound, some two hundred feet high, which originally covered an area of about sixty acres, and now presents the appearance of three distinct terraces, surrounding and supporting a conical hill, very wide, and much overgrown with shrubbery. It is constructed of materials precisely similar to those which make up the plain on which it stands, and appears not to have been all erected at one time, but to be the accumulation of successive periods of labor. Mr. Bandelier believes that the structure was designed to hold immense communal buildings, like those at Pecos, in New Mexico, but in size approaching the great edifices at Palenque and Uxmal, and all built around a vast court, in the center of which stood an enormous "worship-mound," and that it was built by the Toltecs, or Mayas. Mr. Bandelier also visited Mitla, where he secured accurate plans and measurements of the most important buildings, thirty-nine in number. The so-called palaces are not greatly different from the pueblos of New Mexico, and are described as built and ornamented without any knowledge of mechanical contrivances, dark and imperfectly ventilated, and only a "barbaric effort of a barbarous people." His conclusion, drawn from the shape and size of the single apartments, is that they were not intended for every-day abodes, but only as shelters at night and in bad weather, and retreats for the women and children during a hostile attack—communal structures, differing from the similar constructions of other Indian tribes "only in so far as the exigencies of a different climate or of varying resources demanded." M. Louis H. Aymé, United States consul at Merida, has entered into a contract to explore, as agent of the institute, such places in Yucatan as have not recently been examined by Dr. Le Plongeon or M. Charnay. The ruins of Yucatan have suffered great destruction during the forty years since they were visited by Stephens.

The American Association.—The thirty-first annual meeting of the American Association for the Advancement of Science will be held at Montreal, beginning August 23d, under the presidency of Principal J. W. Dawson, LL. D., F. R. S., of McGill University. The headquarters of the association will be at McGill University, where members will register as soon as possible after their arrival. The hotel headquarters will be at the Windsor Hotel. The offices of the local committee and of the permanent secretary will be at the university. The general sessions and the meetings of the sections and committees will all be held in the university buildings. The permanent secretary, Professor F. W. Putnam, may be addressed at Salem, Massachusetts, till August 17th, after which his address will be at the Windsor Hotel, Montreal, Canada.

The British Association.—The fifty-second meeting of the British Association will be held at Southampton, beginning August 23d, when the chair will be resigned by Sir John Lubbock and assumed by Dr. C. W. Siemens, F. R. S., president-elect, with the usual address appropriate to the occasion. The addresses at the evening general meetings will be, "On the Tides," by Sir William Thomson, F. R. S., August 25th, and on "Pelagic Life," by Professor H. N. Moseley, August 28th. The presidents of the sections will be: A, *Mathematical and Physical Science*, Lord Rayleigh; B, *Chemical Science*, Professor D. Liveing; C, *Geology*, R. Etheridge, F. R. S.; D, *Biology*, Professor A. Gamgee, with Professors Gamgee, M. A. Lawson, and W. Boyd Dawkins as presidents in the Departments of Anatomy and Physiology, Zoölogy and Botany, and Anthropology; E, *Geography*, Sir R. Temple, Bart.; F, *Economical Science and Statistics*, the Right Hon. G. Sclater-Booth; and G, *Mechanical Science*, John Fowler, F. G. S. Excursions to places of interest in the neighborhood of Southampton will be made on the afternoon of Saturday, August 26th, and on Thursday, August 31st.

Forests and Climate.—Dr. J. M. Anders, in the "American Naturalist," has carefully examined the influence of forests upon climate and rain-fall. The principal influence exerted by woods upon climate is as wind-breaks, in which capacity the service they render is familiar enough. The experiment has been tried extensively in France of planting trees in belts one hundred metres apart, with marked benefit to the climate. Forests may slightly promote the condensation of moisture by inducing an upward movement of the air, as mountains are known to do on an extensive scale; but their action in this respect, on account of their low height, is not important enough to be made account of. Woods play a more important part in furnishing the air with moisture by transpiration of water through their leaves. It is computed from experimental tests that they give off in this way twelve times as much water as is evaporated directly from the soil on which they stand, twice as much as goes up from a free soil, and more than is emitted from an equal body of water. They are able to do this, and keep it up, because they are at all times supplied with an abundant store of moisture for transpiration. This is given them partly by the power which their roots have to attract moisture from every direction; partly by the retention of the rain-fall in their net-work; and partly by the property possessed by vegetable mold of absorbing moisture and holding it. This power of evaporation is shared by the humbler vegetation, and it operates nearly constantly, even during long droughts. Climate is also materially affected by this quality, for moist air during winter tends to moderate extreme cold and during summer produces a refreshing coolness. Now, since it is established that forests moisten the air over, in, and to some extent around themselves, "may we not be pardoned for concluding that warm currents sweeping over a country and striking the cool moist air in and above the forests, and mingling with it, would have a portion, at least, of the contained moisture condensed into gentle showers, extending their beneficent influence to neighboring fields? Again, let some stray current come along, of a lower temperature than the air of the forest, and the moist air of the forest would readily be condensed, since it is a well-known fact that a moist air discharges its vapor more readily in the form of rain than a drier atmosphere. We have now seen how trees can cause local rains; it will also be observed that the rain is formed chiefly above the forest, though it may be through the influence of winds that it falls to the earth for some distance around. By increasing the frequency of light rains, forests tend to obviate drought, which is of ultimate importance to the farmer's crops and vegetation in general. It will be seen that all our deductions have been drawn largely from the known facts from observations." Forests also produce abundant dews, an office not to be despised, for heavy dews are often very refreshing to vegetation.

Atmospheric Pressure and the Sea-Level.—One of the most interesting phenomena of the recent winter in Europe was a remarkable depression of the level of the Mediterranean Sea under the influence of the high barometric pressures of December

and January. At Antibes, in particular, the water-level sunk considerably, falling about a foot during the first fortnight in January, and laying bare bottoms over which small boats had previously sailed with ease. A similar depression was noticed on the coasts of Italy, particularly at Fiumicino. A French *savant*, M. Daussy, has estimated the amount of this influence, and calculated that it is equal to the product of the excess of height over the normal by the density of mercury. The action of atmospheric pressure is so manifest at other points in the Mediterranean, according to Dr. Niepce, of Nice, that it almost alone constitutes the tidal force. The fact is confirmed in a paper on the climate of Venice, which has recently been published by M. Tono, of the Meteorological Observatory in that city, which shows the closest correspondence between the changes in atmospheric pressure and the rise and fall of the waters.

The Mound-Builders and the Southern Indians.—Dr. Daniel G. Brinton has sought to answer the question, Who were the mound-builders? by inquiring whether and to what extent the tribes who inhabited the Mississippi Valley and the Atlantic slope were accustomed to make works similar to the mounds. It is clear, from several accounts, that the Iroquois were accustomed to construct burial-mounds, and their neighbors, the various Algonquin tribes, occasionally raised heaps of soil. The Cherokees do not appear to have been real mound-builders, but they appreciated the convenience of mounds, and put their more important buildings upon them when they had them at hand. The tribes among whom we can look for the descendants of the mound-builders with the greatest probability of success are the tribes of the great Chahta-Muskokee family, which includes the Choctaws, Chickasaws, Creeks, Seminoles, and Natchez. They "seem to have been a building race, and to have reared tumuli not contemptible in comparison even with the mightiest of the Ohio Valley." Cabeza de Vaca, who accompanied the expedition of Pamfilo de Narvaez in 1527, mentions a place where the natives were accustomed to erect their dwellings on a steep hill, and dig a ditch around its base, as a means of defense. All the accounts of those who participated in Hernando de Soto's expedition describe the Southern tribes as constructing artificial mounds, using earthworks for defense, excavating ditches and canals, etc. Thus, La Vega tells how the caciques in Florida formed earth into a kind of platform "two or three pikes in height, the summit of which is large enough to give room for twelve, fifteen, or twenty houses, to lodge the cacique and his attendants. At the foot of this elevation they mark out a square place, according to the size of the village, around which the leading men have their houses." Biedma says that the caciques of a certain region "were accustomed to erect near the house very high mounds (*tertres tres-élevées*), and there were some who placed their houses on the top of these mounds." The Huguenots who attempted to settle in Florida described similar structures as marking the sites of the houses of the chief. William Bartram, the botanist, who visited the Creeks in the last century, found that they had "chunk-yards" surrounded by low mounds of earth, at one end of which, sometimes on a moderate artificial elevation, was the chief's dwelling, and at the other end the public council-house. Large burial-mounds are also often spoken of as being made by these tribes. Many of the mounds in the Gulf States are very large. One in the Etowah Valley, Georgia, has a capacity of one million cubic feet. The Messier mound, near the Chattahoochee River, contains about seven hundred thousand cubic feet, and is twice as large as the great mound near Miamisburg, Ohio. Dr. Brinton's views are parallel, if not identical, with those worked out by the late Mr. Lewis H. Morgan, in his "Houses and House-Life of the American Aborigines."

The Microbe of Malaria.—M. Richard, a French pathologist, announces that he has discovered the parasite of malaria in a microbe which makes its special habitat in the red globule of the blood, where it is developed in a similar manner with the weevil in the bean, and whence it issues as soon as it has reached the perfect state. When the blood of a patient suffering from an attack of fever is examined, red globules will be

found, having a little round, clear spot in their depth, but which otherwise preserve all the appearance and elasticity of the normal red globules; they are simply, if the expression may be allowed, stung. Besides these globules, others exist in which the evolution of the microbe is more advanced; the clear spot has become larger, and is surrounded as if by a setting of fine black granulations; all around, the hemoglobine, plainly distinguishable by its greenish-yellow tint, forms a ring, which grows narrower as the parasite increases in volume. At last, nothing is left of it but a perfectly colorless, narrow marginal zone, the hemoglobine having entirely disappeared, and the substance of the red globule having been taken possession of by the microbe till it has been reduced to a shell. We now have a circular element having nearly the dimensions of the red globule, and inclosing the microbe, which has reached its perfect condition, and is provided with one or more very slender prolongations, which are, however, not visible in this condition. At this moment the parasite is about to pierce the membrane that contains it, and escape into the plasma of the blood. This microbe can be found in every patient about to be attacked with fever, except those suffering from marsh-cachexy, concerning whom M. Richard can not speak decidedly, because he has not made sufficient examinations of them.

Geological Influences in English History.—Professor Archibald Geikie has an article in "Macmillan's Magazine" illustrating how the history of the English people has been affected by the geological structure of their island. That the relation thus assumed is real may be proved by viewing the contrast between the heart of England and the heart of Scotland. The former is inhabited by a rich agricultural or busy mining English-speaking population, is dotted with large cities, and teems in every element with the bustle of enterprise; the latter, a region of rugged mountains and narrow glens, is tenanted by a Celtic race that clings to its old tongue and habits, has never built towns and hardly villages, abounds in pastures and game-lands, but has no industrial centers, no manufactures of any kind, and only a feeble agriculture struggling for existence along the bottoms of the valleys. These differences prove, upon examination, to have arisen fundamentally from the utterly distinct geological structure of the two regions, by which diversities in human characteristics were initiated in far prehistoric times, and have been continued, in spite of the blending influences of modern civilization, down to the present day. Passing by the conjectures as to what may have happened in prehistoric times, and between the Cymric and Gaelic branches of the Celtic race, we come to the Roman conquest, which was extended over the lowland regions of the Old Red Sandstone and Carboniferons strata of England and Scotland, and was stopped at the crystalline rocks of the Highlands. The same geological influences which guided the progress of the Roman armies may be traced in the subsequent Teutonic invasions of Angles, Saxons, Jutes, and Norwegians. It was on the former platforms of undisturbed strata "that invaders could most successfully establish themselves. So dominant has been this geological influence, that the line of boundary between the crystalline rocks and the Old Red Sandstone, from the north of Caithness to the coast of Kincardineshire, was almost precisely that of the frontier established between the old Celtic natives and the later hordes of Danes and Northmen. To this day, in spite of the inevitable commingling of the races, it still serves to define the respective areas of the Gaelic-speaking and English-speaking populations." On the northwestern coasts of the island there are none of the fringes of more recent formations which have had so marked an influence on the eastern side. Hence, though the Norsemen possessed themselves of every available bay and inlet, driving the Celts into the more barren interior, the natural contours made it impossible that their hold on the ground should be so firm as that of their kinsmen on the east. Hence the Gaels eventually came down upon them, and all obvious trace of the Norse occupation disappeared, save in the names given by the sea-rovers to the islands, promontories, and inlets. The difference in the character of the Irish and the Highlanders—both Celts—may be traced to differences in geological structure and scenery. The Irishman is

light-hearted and impulsive, because he lives in an easy country, with a soft climate and rich soil. The Highlander is rugged and stern, because his country, where "he has to fight with the elements a never-ending battle, wherein he is often the loser," is so. The apportionment of lands into cultivated, pasture, and feral lands, rests upon geological causes, which determine that each tract shall be used for the purposes by which the most can be made out of it. The sites of towns and villages may often be traced to a similar influence. Formerly they were built around heights that could be fortified; now they are built where the geological features afford the most scope for industrial and commercial development; and the latter towns are the ones that are growing, and to which the population is being transferred at the expense of the others. The style of architecture, which is largely determined by the presence or absence of building-stone, and the kind of the stone or clay, is obviously related to geological features. Lastly, "the history of the development of our system of railways, our steam machinery, our manufactures, is unintelligible except when taken together with the opening up of our resources in coal and iron," and these are traceable wholly to geological features.

A New Weighing of the Earth.—Professor von Jolly, of Munich, has recently employed a new process for the determination of the mean density of the earth. He placed a pair of scales in the top of a tower, and attached to each plate of the instrument a wire which reached, passing through a zinc tube, to twenty-one metres below. To the lower ends of the wires other scale plates were suspended, which thus hung within a little more than a metre of the ground. Under one of the lower plates he put a ball of lead, a metre in diameter. The fact that a body at a certain elevation gains in weight as it is brought nearer to the ground was verified by weighing bodies first in one of the upper balances and then in one of the lower ones. Furthermore these bodies varied in weight in the lower plates according as the mass of lead remained under them or was taken away. The differences in these weights showed the degree of attraction exercised by the mass. The value thus obtained, compared with the attraction exerted by the earth alone, furnished a means of ascertaining, according to the laws of gravitation, the ratio between the density of the earth and that of lead, and, the latter being known, of determining the mean density of the globe. M. von Jolly's experiments give this density as 5·692, with a probable error of $\pm 0{\cdot}068$, a figure that agrees quite well with other determinations, particularly with Bailey's of 5·67.

Recent Applications of Science to Machinery.—Sir Frederick Bramwell took as the subject of his chairman's address at the recent opening of the 128th session of the Society of Arts, the later applications of science to the promotion of arts, manufactures, and commerce. It could not be said, he remarked, that any new scientific discovery or principle has been applied to the steam-engine, which is still our pre-eminent motor, but the principles on which its economical action depends have been advanced by the application of jacketing for saving steam and the use of higher pressures, with a consequent economy of coal. Available pressures have increased during the last half-century from three and a half pounds to one hundred pounds; and Mr. Loftus Perkins has engines running with four hundred pounds of pressure above that of the atmosphere, demanding a consumption of one and two thirds of a pound of coal per indicated horse-power per hour against two and a half pounds required by engines using a pressure of one hundred pounds. The saving, five sixths of a pound, seems small when expressed in simple figures, but it represents a considerable percentage, and the difference between running a vessel fourteen days and twenty-one days with the same stock of coal. Nevertheless, unless some wholly new and at present undreamed-of discovery is made, the steam-engine will have to yield its place to other means of obtaining motive power. The average of British engines do not give forth one twenty-fifth of the energy that may be considered as residing in the fuel they consume; and even if we should obtain a horse-power per hour for as little as one pound of coal, we should still utilize only about a sixth or a fifth of that energy. The opera-

tion of railways has been improved by the introduction of steel rails, the extension of the block and interlocking systems, the application of continuous brakes, and the better adaptation of rolling-stock to turning curves; and the use of steel for cross-ties is anticipated. Arrangements are in use by which the signal-man can cause the whistle of the engine to sound at the same time he gives the danger-signal; and a device to enable him also to turn off the steam, apply the brakes, and stop the train is desirable and not impracticable; but this should be accompanied with a registering apparatus to reveal the negligence of the engineer that may have made it necessary to apply it. So much has been gained in our knowledge of the theory of resistance and the best dimensions and shapes of ships, that we are now able to build vessels approaching the size of the Great Eastern, and run them with a profit at a greater speed than was ever attained before. Gas-engines are made, the workings of which are nearly as steady as those of the steam-engine, and with Mr. Dowson's process for making fuel-gas, power can now be obtained from gas-fuel for less cost than in the ordinary steam-engine. A curious application of shifting ballast, which was once thought to be one of the most dangerous agents to equilibrium, has been made in the British war-vessel Inflexible to check the rolling of the vessel. Water, in a tank extending across the vessel, by being on the lower side at the moment the vessel turns to roll upon the other side, and remaining there till the position of equilibrium is reached, restrains the violence of the oscillation, diminishes its extent, and tends to bring the vessel sooner to rest.

Scientific Societies in Japan.—Besides having several bodies in the nature of learned societies which have enjoyed a time-honored existence, the Japanese have been prompted, under the impulse given by the introduction of European culture, to found several new scientific associations. The most important of these bodies is the Geographical Society of Tokio, with two hundred members, among whom are included several of the chief personages of the empire. Its "Transactions" are neatly printed in pamphlets of about one hundred pages each, and contain much matter, especially the papers relating to Corea, that is valuable to European geographers. A biological society was established while Professor Morse, of Salem, Massachusetts, was connected with the University of Tokio, and is now conducted by Professor Yatahe, a scholar educated in the United States. The *Kojunsha*, or Society for the Circulation of Knowledge, has branches in nearly every town of importance in the empire. A member desiring information on any subject applies to the secretary, who finds on his books the names of any persons who are likely to satisfy the applicant, and transmits his questions to him. The answers are forwarded to the inquirer, and, if important enough, are printed in the weekly "Journal" of the society. This association has nearly three thousand members, some of them in Europe and America. The Seismological Society has been instituted for the study of earthquakes, for which Japan offers rare facilities. It is given the use of the telegraphs by the Government for the instantaneous transmission of news of phenomena happening in any part of the country. The Numismatic Society, one of the old native societies, is very active, and publishes a periodical describing the new and strange coins that are exhibited at its meetings. The Antiquarian Society and the Society of *Go*-players are also ancient native organizations that still flourish.

A New Race in Course of Development.—M. Gustave Le Bon has called attention to a peculiar race living in the Tatras Mountains, the process of whose formation out of the neighboring peoples, from whom it is now isolated, he believes can be traced quite clearly. It is the people called the Podolians. They are surrounded on different sides by Ruthenians, Slovacks, Magyars, Germans, and other races, yet are distinct from them in many of the most essential characteristics. Their land is walled by a circle of mountains difficult to traverse, which interpose an effectual physical separation between them and the races dwelling on the other side; the climate is rigorous, the soil poor, and adapted to the production of so limited a

number of crops that their food is almost entirely confined to oatmeal, and milk, or its products. Under such conditions only the most vigorous children can survive; consequently a natural selection has been going on for centuries, by the operation of which the people have acquired a superior stature and cranial capacity. The legends and traditions go back to a period when the people's ancestors were all brigands, and were at the same time very religious, and when their moral and religious sentiments were wholly independent of each other, or, we might say, contradictory. They were accustomed never to start off on a predatory expedition without invoking God and the saints for the success of the enterprise, and the legends are full of testimonies of the protection that Heaven accorded to the robbers. The Church of St. Anne, at Nowy Targ, it is said, was built by thieves as a thank-offering for the care the Lord took of them in one of their expeditions! The population appears to have been produced from crosses of the neighboring races, which ceased after it became considerable enough to take care of itself, and it has consolidated its traits under the immediate influences of its environment. The Podolian territory, protected by its inclosure of steep mountains, was in the old times the refuge of the outlaws of the neighboring country, who met there and laid the foundations of the present race. The chief element in the composition was probably furnished by Poles, whom the Podolians resemble in psychological traits and language more than they do their other neighbors. Next in importance, perhaps, were the Slovacks, with whom linguistic affinities are traceable. The mental traits, tastes, and culture of the Podolians are peculiar, and in some respects incongruous with the conditions of their life. They are addicted to letters, music, and poetry, and are very religious. The only one of the races around them that share these tastes is the Ruthenians, but they are at the same time capricious in disposition, and lacking in energy, activity, and perseverance, while the Podolians are the opposite. We must infer, then, that the Podolians derive their refined tastes by inheritance from Ruthenian ancestors, while their more vigorous qualities have been developed under the influence of the struggles which they have had to maintain with the physical conditions of their country. The superior cranial capacity of the Podolians, which is remarkable, is likewise probably owing to the constant draft which circumstances have made upon their resources and the activity of their intelligence.

Fossil Insects.—Mr. H. Goss has recently concluded a series of papers reviewing the studies of several paleontologists in fossil insects. The hexapod insects constitute, after the crustaceans, the most numerous class of ancient articulates with which we are acquainted. Remains of their wings, quite distinguishable, are found in the Devonian formations of America and the Carboniferous of Europe. Myriapods appear first in the Trias; and Arachnids had not, until scorpions were recently discovered in the Carboniferous of Scotland, been found below the Jurassic. The two most ancient insects known are two which Mr. Scudder has described from the fern-marked Devonian strata of New Brunswick, one of which is allied with the *Neuroptera*, or dragon-flies, the other with the *Orthoptera*. These classes seem to have the field to themselves till the Carboniferous period, when the *Hemiptera* and *Coleoptera* (and our Scottish scorpion) first appear. The most common insects of the Palæozoic and Mesozoic epochs appear to be of the family of the cockroaches, which are very abundant in both continents, and which Mr. Scudder has made the subject of a special monograph. Insect remains become more abundant in the Jurassic epoch. A certain limestone of the English Lias is so full of them that it is called the insect limestone. The *Coleoptera* are most numerous, probably because their horny elytræ better resist decay, but *Hymenoptera* and *Diptera* also are found at Solenhofen and Purbeck. The cretaceous and tertiary beds, however, have furnished the largest number of specimens that have been studied by paleontologists, the multiplication of insects having, it seems, been greatly favored by the prevalence of angiospermous vegetation. The *Lepidoptera* appear last, and are rare, not more than ten authentic types of them having been recognized. Certain beds, such as those of Solenhofen, Aix in Provence,

Œningen in Switzerland, Radoboj in Hungary, Monte Balca in Italy, and the Florissant basin in Colorado, are celebrated for the rich harvests of insects they afford. The nature of the deposits seems to have exercised some influence upon the greater or less frequency of certain types, for each of these beds is distinguished by the prevalence of particular types. Elytræ are found in quaternary beds, which have largely preserved their metallic luster. A curculiform found in England has a tropical grandeur of size. Most of the later fossil species on the Continent are identical with those now living in Europe. Fossil insects present but few of those strange gigantic forms that astonish us among the other classes of animal remains. The largest and most curious forms found are still surpassed in tropical countries. The insects which occur in the Lias, among the remains of monstrous pterodactyls and extinct saurians, are all of families that are still represented in life; and the oldest insects of the Devonian could be inserted among living *Orthoptera* without disturbing the symmetry of the order.

Sewage-Irrigation in German Cities.—M. Durand-Claye, a sanitary engineer of Paris, has published a report on the systems which are employed in the German cities of Dantzic, Berlin, and Breslau, for the final disposal of sewer-water. The systems of filtering and of precipitation by chemical agents were tried, but were found not to effect a sufficient purification; and irrigation was finally chosen as furnishing on the whole the most economical and satisfactory method. The water is cleansed of its grosser solids before being pumped up from the sewers; it is afterward conducted to the irrigated tracts. At Dantzic the sewage is turned upon a tract of about twelve hundred and fifty acres of a sandy, arid soil, and is led around beds devoted to the culture of garden vegetables. The surplus water, which is drained off to the Vistula, has been proved to have lost seven eighths of its organic matter, five sixths of its ammonia, and one half of its mineral impurities. The ground has an excessive absorbing power, and it has been necessary to box the main conduits to have any water left for the smaller irrigating channels. Thus far, four hundred and seventeen acres have been enough to absorb all the sewage of the city, indicating an absorbing-power of thirty-two thousand cubic metres a year for each acre. The works have been made and are kept up without cost to the city, for the use of the irrigated lands for thirty years; and the land is sublet to gardeners for from twenty to twenty-eight dollars an acre. The mortality of the city—one of about one hundred thousand inhabitants—has been reduced twenty-one per cent under the operation of this system. At Berlin, after some unsatisfactory experiments with chemical agents, irrigation was tried on about fifteen acres of land. The tract took in and purified 281·618 cubic metres of water in a year and nine months, and returned good crops. The municipality determined to treat all of its sewer-waters in the same way, and bought two tracts, one of seventeen hundred and forty acres, the other, at Osdorf and Friederickenhof, of two thousand and sixty acres. One thousand and eighty acres of the latter tract only have been used. In addition to the cultivated plats, drained basins are provided for the water that is not needed on the crops, in which, after a deposit about a foot thick has accumulated, the ground is dried, dug up, and made ready for cultivation in the next year. The waters thus treated cease to give off odors and lose all unhygienic properties; the health of the workmen and the comfortable occupation of the neighboring country seats are not affected by them. The cost of managing the lands is defrayed by the sale of products, so that the city is only at the expense of pumping up the water, while it is able to let the lands at from twenty-four to thirty-four dollars an acre. The city of Breslau uses a tract of about twelve hundred acres, of such a character that extra drainage is necessary. The irrigated lands are let to the engineer who constructed the works at a scale of rents which is to rise in four years to eighteen dollars an acre.

The Salt Deposits of the Persian Gulf.—On the eastern side of the Persian Gulf is an extensive area containing a large deposit of salt which crops out at various

places and rises into ranges of rocks of considerable magnitude. The salt-bearing rocks are of a reddish color, receiving their tint from red ochre, which, associated to a small extent with specular iron, covers the salt deposit and is more or less mixed with it, imparting to it also a red tint. The association of ochre with salt is so constant in the district that the existence of the former is almost a sure indication of the presence of the latter. Near the villlage of Kowin on the Island of Kishm, the salt and ochre are so mingled in a part of the range as to give it the appearance of a structure made of red bricks and mortar. Years ago, the salt was gathered from hollows in the ground where briny water issuing from the rocks could be collected and the mineral would be left after evaporation in beautiful crystalline masses. More recently, the salt has been quarried; and the works conducted for this purpose have become large caverns in which stalactites have been formed from the trickling of the brine, yielding snow-white masses of saccharoid salt. Besides these masses, the salt is found here in pure white lumps, easily reduced to granules, the most valuable form, red, stony masses which are used chiefly for salting fish, and translucent and transparent masses of cubical forms, and is dug out with crow-bars. At Hameran, four miles from the sea-shore, the salt is found in beds about four feet thick with intervening layers of earthy material, and is sometimes of a pale-greenish color from contact with an earth containing manganese. The masses in these beds are broken with gunpowder and granulated with mallets. Warm springs charged with salt are found close by the village of Salakh, near Henjam, yielding a reddish naphtha which the natives use for purposes of light and for rheumatic complaints.

The Great Arctic Forest.—Professor Nordenskiold, in his "Voyage of the Vega," describes what he calls the greatest forest the earth has to show. It exists in the country of the Yenisei River, and extends from the fifty-eighth or fifty-ninth degree of latitude to far north of the Arctic Circle, in the neighborhood of the sixty-ninth degree of latitude, covering an extent of about one thousand kilometres from north to south, and perhaps four times as much from east to west. "It is," he says, "a primeval forest of enormous extent, nearly untouched by the axe of the cultivator, but at many places devastated by forest-fires. On the high eastern bank of the Yenisei the forest begins immediately at the river-bank. It consists principally of pines. . . . Most of these already north of the Arctic Circle [the traveler is supposed to be going from north to south] reach a colossal size, but in such a case are often here, far from all forestry, gray and half-dried up with age." The ground is covered with fallen branches and stems in all stages of rottenness, which are covered, often concealed, by an exceedingly luxuriant bed of mosses, while tree-lichens occur sparingly. "The pines, therefore, want the shaggy covering common in Sweden, and the bark of the birches which are seen here and there among the pines is distinguished by an uncommon blinding whiteness." Evidence was collected to show that the limit of trees in the Yenisei region has extended, even during our geological period, farther north than now.

Mud-Volcanoes in Sicily.—Two eruptions of mud in places remote from each other, and offering different and remarkable characteristics, are under observation in Sicily. One is taking place in the interior of the island, about eight miles north of Girgenti. It proceeds from a mountain about three hundred feet high, called Macaluba, the flattened summit of which is dotted with small cones, each containing a funnel-shaped crater, from the bottom of which a bubble of mud rises and bursts every minute. The other eruption is near Paterno, on the western side of the lower region of Etna, nearly forty miles west of Macaluba, and takes place in openings and small cones on the level of the surface. It is considerably more violent than that of Macaluba. The mud spurts out in jets several yards high, and forms a large fuming lake, which runs into the bed of the river Sinet. The eruption has been renewed three times within a year, and is at present accompanied with deep subterranean rumblings and strong tremors of the earth, some of which are perceptible several miles away. The mud that issues from these volcanoes is saline

and petroleum-bearing. A kind of scum of petroleum may be seen on the edges of the craters of Macaluba. The gases escaping from them contain from thirty-four to thirty-six per cent of carburetted hydrogen, with sulphuretted hydrogen and carbonic acid. The soil around Paterno, in which the center of the second eruption is situated, is calcareous, and abounds in springs containing carbonic acid. The waters, infiltrating the soil, raise its temperature and form a kind of veined alabaster, which is much esteemed. The eruptions are occasioned by the passage of carburetted hydrogen, which is formed by the decomposition of organic matters within the earth, in seeking its way to the surface through beds of clay which have been washed down into the crevices. Mud-volcanoes of another kind, of which those of New Zealand and Iceland afford examples, are formed by vapors of water proceeding from ordinary volcanoes, and are distinguished by the high temperature of the mud and the absence of carburetted hydrogen.

The Oldest Flowering Plant.—MM. G. de Saporta and A. F. Marion have been studying the genera *Williamsonia* and *Goniolina*, the most ancient angiospermous plants of which the fructiferous organs have been preserved. The stem bears at its extremity reproductive apparatus in which two different modes of structure, indicating a diœcious plant, may be distinguished. A many-leaved involucre, having its bracts so curved as to give it a globular appearance, is observed in every case. The parts of the male involucre are disposed in a single row, connivent, elongated, and attenuated at the end. The organ represents a conical axis, the base of which is surrounded with a circular zone marked with radiating striæ. The outer edge of this zone, when it is exposed, is occupied with a collection of very small compartments of irregular hexagonal contour, that seem to represent as many pollen-boxes. This basilar zone corresponded with a sterile and persistent portion of the androphore, which in its integrity probably covered the whole conical receptacle with a matted layer of staminal appendages, recalling by their disposition and office the male organs of the *Typhas*. The female organs of the *Williamsonia* are provided with the globose involucre of the male flower, except that the bracts are a little shorter. The organ contained within this involucre, which was certainly caducous at maturity, consisted of a receptacle or spadix in the form of a more or less globose solid cushion. The central leaves of the involucre, which remain in place, testify by their thickness to a particularly tough primitive condition. The spadix in the midst of them is covered on its upper part with carpellary compartments, while the fibro-ligneous tissue which composed the axis of the receptacle is recognizable in the lower part.

French Exploring Expeditions.—Since 1874 the French Government has authorized the organization of three hundred and thirty scientific missions, of which one hundred and sixty-eight were to operate in Europe, fifty-four in Africa, forty-eight in Asia, thirty-six in America, and twenty-four in Oceania. Most of these missions are still at work, and generally report to a commission appointed by the Minister of Public Instruction. The "Revue Scientifique" reviews the condition of the most important of the missions, particularly of those which relate especially to geography. M. Lantz is in Madagascar, studying the natural history of the less accessible parts of the island; M. Pélagaud is exploring the Mascarene Islands; M. Montano, Malaysia; and M. Marché, the Philippine Islands. In Africa, M. Matheis is exploring the region between the Niger and the Bénoué; M. Revoil is examining the Somauli country from Cape Guardafui to the Strait of Bab-el-Mandeb; Messrs. Savorgnan de Brazza and Ballay are supplementing Stanley's work on the Congo; Messrs. Roux, Cagnat, and Gosselin are studying the geography and archæology of Tunisia; M. Galliéni has concluded a treaty for the navigation of the Niger to Timbuctoo; and several expeditions are engaged in the eastern part of the continent. In Asia, M. Haas is pursuing artistic and historical investigations in Hindostan; M. Chantre has started from Bagdad to look into the anthropology and zoölogy of the region of the Caspian Sea and Mount Ararat; M. Clermont-Ganneau is engaged in archæological work in the east of

Egypt, in Philistia, and Phœnicia; M. Cotteau is making his way through Russia and Siberia to Japan. M. Wiener is traveling through South America; M. Pinard, having done some work in Alaska, is engaged in California, New Mexico, and Arizona; and M. Charnay is digging in the ruins of the ancient cities of Mexico. In Europe, M. Georges Pouchet is studying the glacial fauna of Norway; M. Dieulafait is investigating the formation of rock-salts and gypsums in Switzerland; M. Milne-Edwards, as the head of a commission, is about to engage in deep-sea researches in the Mediterranean; and several parties are exploring the Alps and the Pyrenees.

Is the Moon red-hot?—Mr. W. Mattieu Williams believes that the surface of the moon has an intrinsic brilliancy of its own, and a temperature much greater than is usually supposed. He expresses the opinion, in effect, that the surface of the moon is, as it appears to be in eclipses, "of a dull-red heat, and that this high temperature is due to the action of the sun's rays striking it directly, without any intervening shield of aqueous vapor or other atmospheric matter. If the volcanic tufa, of which the moon's surface is evidently composed, resembles the corresponding material on our earth, it is one of the best absorbers of heat and the worst of conductors. This being the case, the uninterrupted glare of the sun's rays would produce its maximum possible effect on a thin film of the moon's surface. . . . We must remember that a dull copper-red heat, just visible in the dark, is considerably below the temperature of red heat visible in daylight. Supposing the color of the moon to be due to such heat, I should estimate its surface temperature at a little above 600°." Lord Rosse, estimating the surface temperature of the moon, concluded it was about 500°. Mr. Williams was led to his conclusion by watching the appearance of the moon during the totality of an eclipse. When the partially eclipsed moon rose, the shaded part displayed a full copper-red color; as the eclipse progressed, this advanced to a darker or more obscure copper-color; then the redness gradually faded, and the shaded portion of the moon grew darker and grayer, until at last it became of a dark slate-color; and its outline or limb was barely traceable toward the end of the eclipse. In some elementary treatises this copper-color is attributed to "the refraction of the sun's light by the action of the earth." Mr. Williams fails to see how this can operate in the middle of the shadow, where the color is the most decided, and why it should fade as the eclipse progresses, and finally be lost just at the outer edge of the shadow. The fading is easily accounted for on Mr. Williams's hypothesis, as the result of the rapid cooling of the lunar surface on the withdrawal of the sun's rays. The reasoning that ascribes so high a temperature to the side of the moon presented to the sun must lead to the conclusion that the dark, or night side, is intensely cold.

The Original Home of the Aryans.—Dr. Fligier argues in "Kosmos" that the theory of the Asiatic origin of the Aryan race is not yet as firmly settled as has been supposed. Latham disputes it on geographical grounds in his "Native Races of the Russian Empire." Pictet believes, on the evidence of the names of animals and plants that were known to them, that they originated farther north than the Asiatic theory supposes, and fixes their birthplace in Southern Russia. Benfey and Professor Tomaschek, of Grätz, agree with him, and indicate the region of the southern Volga as their primary home, whence they may have spread to the Carpathian Mountains on the west, and to the marshes of the interior and the Ural on the east. Bogdanoff has found dolichocephalous skulls of the recognized type of the German giant-graves in the Kurgans of Moscow. Resemblances between Finnish and Aryan and between Magyar and Iranian words indicate that those people were respectively neighbors to each other in their old times, as might have been the case if the theory of the European origin of the Aryans is true. Dr. Fligier believes that the results of linguistic, anthropological, and archæological researches indicate that the Indians and the Iranians lived near each other for a long time in Eastern Europe or Northwestern Asia, and that the Indians followed the Iranians into Asia. That this happened at a comparatively late period is presumed to be shown by the fact that these

peoples are not mentioned in the older Babylonian cuneiform inscriptions, and are first spoken of in the Assyrian inscriptions of the ninth century B. C. A second Aryan emigration to Asia followed across the Hellespont. After making a detailed examination of the Aryan stocks and their supposed emigrations, Dr. Fligier concludes that their linguistic unity does not by any means constitute an anthropological unity: the Asiatic Aryans have partly lost their Aryan type, and the European Aryans present two quite distinct types.

Observations of the Last Solar Eclipse.—The solar eclipse of May 19th has been the subject of a number of communications to the French Academy of Sciences. M. Janssen spoke in terms of admiration of the photographs of all the phases of the phenomenon which were obtained by means of the photographic revolver. A very laconic notice of the observations made during totality by Messrs. Trépied, Lockyer, Thollon, and Tacchini, was sent by telegraph. The Egyptian Government gave exceptional facilities to the observers. Photographs of the corona and its spectrum were obtained, the latter exhibiting the lines of potassium and hydrogen. The observers at the same time noticed a comet which was visible to the naked eye in the immediate vicinity of the sun. At Lyons M. André and his aids saw between the edge of the moon and the outline of the sun-spots which it was approaching, the development of the gray ligament that has been noticed between the edge of the sun and the circumference of the planets crossing its disk. The popular observatory of the Trocadéro, in Paris, on the day of the eclipse, put four telescopes, as many opera-glasses, and blackened glasses, at the service of the public. About a hundred persons were present as early as six o'clock in the morning. Each instrument was in charge of an assistant, whose duty it was to help the public to see the phenomenon. One of the assistants made a projection apparatus of his telescope, and threw an image of the eclipse and of numerous solar spots upon a screen, where it could easily be looked at by fifteen persons at once. It was thus made possible to examine with the microscope the details of a considerable number of spots, and to see the black profiles of the lunar mountains designed on the illuminated image of the sun. Several drawings of the solar spots and the eclipse were taken.

An Insect-lodging Flower.—M. Treub has made a study in Java of the *Discidia Rafflesia*, a curious plant which lives upon trees without touching the ground. It produces urns in the shape of jars open at the top, and containing within a system of branched roots. After showing that these formations are produced by the folding of a leaf upon itself in such a manner that its lower face corresponds with the interior face of the urn, M. Treub inquires what may be the office of the organs. The fact that the interior of the urn is lined with a waxy coating precludes the idea that it can directly serve a carnivorous purpose. Against this, too, are the facts alleged by M. Treub, that ants which are found in the urn are always very lively and generally very numerous; that they come out of the urn as easily as they go into it; and that they swarm in it to such an extent that the roots suffer from them, and the radicels are eaten or are very weak. These insects, then, seem rather to devour the discidia than to serve it as food. M. Treub concludes that "the urns of the discidia are of no use to it as traps for insects. The plant is not in any sense carnivorous. Instead of falling into an ambuscade, the ants that enter an urn find there a lodging that suits them marvelously. The principal, if not the sole, function of the urn is to collect, or, in a lesser degree, to save water." M. Treub shows further that the water in the urns is generally rain-water, more rarely transpired water, that may perhaps be afterward reabsorbed by the plant.

Calculating the Area of the United States.—Mr. F. Y. Carpenter, C. E., has explained in "Van Nostrand's Engineering Magazine" the difficulties which are encountered in making an accurate computation of the area of a large country like the United States, having irregular boundary-lines. The principal difficulty arises from the indeterminateness of the expression, "our territorial outline." The place, even, of the sea-line

is not fixed. Tradition, not law, sets it at three miles out from shore, but the Spaniards in Cuba have claimed six miles, and most nations now have guns capable of enforcing their jurisdiction over that distance. It is impossible to determine by a fixed rule what waters between headlands shall be included as a part of the territory. It seems obviously proper to include landlocked bodies of water; but should Lake Michigan be admitted to this category? Mr. Carpenter decides that it should. A convention between France and England made in 1839 defined the coast-line as one that should cross the mouths of all bays and channels not more than ten miles in width. This would exclude Chesapeake Bay, which is fifteen miles wide at its mouth, but is evidently as much a part of the United States as Seneca Lake. Lords Hale and Hawkins would have had the ocean boundary cross such inlets as are so narrow that "a man may reasonably discern from shore to shore"; and Justice Story thought the vision should be required to be distinct and with the naked eye; Wheaton would include the ports, harbors, bays, mouths of rivers, and adjacent parts of the sea inclosed by headlands; and Willcock, saying that it may be regarded as generally accepted that bays or channels within the horns of promontories, however large, are subject to the sovereign of the neighboring land, has given a definition under which our Atlantic coast might be considered to extend in a straight line from Maine to Florida. The effect of elevation over the sea upon the area of a tract is also considered by Mr. Carpenter. All tracts the measurement of which is taken in degrees and minutes, gain in extent as their height above the sea is increased, for they are there a part of a larger sphere than one whose perimeter is defined at the normal level. Colorado, having a mean elevation of 7,050 feet, is estimated to gain in consequence 44,800 acres, or seventy square miles. Estimating the mean altitude of the whole United States at 2,600 feet, the country is 800 square miles larger than it would be if it were all down at the level of the sea. A district or country otherwise gains in superficial area of land if it is mountainous, by reason of the slope of its hills. It is impracticable as yet to determine the actual gain from this source for any State; but if Colorado is supposed to have an average slope of ten degrees, it gains an additional area of 1,600 square miles; if its slope is five degrees, its gain is 400 square miles. Taking a mean of these figures, it seems safe to say that Colorado is indebted to its mountains for at least one thousand square miles of area, which has never yet been included in any statement of its geographical extent.

Tastes and Smells in Water.—Dr. William Ripley Nichols, in a paper on "The Tastes and Odors of Surface Waters," calls attention to the desirability of competent persons trained to scientific observation undertaking systematic daily examinations of the water in reservoirs for long periods of time—say for five years—to watch the changes that take place in its condition and the causes of them. He also notices that the means by which water may be made unpleasant are numerous and complicated, and are not always animal in their origin. The worst smell that he ever obtained was from allowing the seed parts of a species of *Potamogeton* to decay in water. Professor Brewer has obtained a fishy odor from the decay in water of the leaf-stalks of a pickerel-weed. Sometimes the odors and tastes from various plants differing from each other seem to blend into a more or less marshy or pond flavor. The water of ponds and lakes that are surrrounded by woods acquires more of a bitter or astringent taste, that may be referred to the dead leaves. When a recently felled tree is exposed to the action of water, or when bushes or grass and weeds are killed by being flooded, the sap and more soluble matters are leached out and putrefy or undergo other forms of decomposition. If the matter is alternately flooded and left bare, decay takes place fast. As the level is lowered, those aquatic plants which grow in shallow water die, and if the water rises after a short interval it becomes impregnated with the products of their decay. If a considerable interval elapses, land-plants grow upon the exposed surface, and, being drowned by the rising waters, tend to its contamination in the same manner. The substances which form the most offensive

part of the soluble vegetable matter are albuminous in character, and the chemical effect on the water is to increase the amount of what is called "albuminoid ammonia." No doubt dead fishes and animalcules and their excrement add to the nitrogenous organic matter in surface-waters, but their presence is not necessary to account for bad odors. As a rule, in waters not contaminated with sewage, the animal matter forms only a trifling proportion of the entire organic matter, but the recent investigation of Professor Remsen shows that in some instances the animal matter, as from sponges, may be appreciable and of practical importance.

Old and New Latitudes on the Atlantic Coast.—The Rev. Edmund F. Slafter, of the New England Historic Genealogical Society, has published an inquiry into the history and causes of the incorrect latitudes as recorded in the journals of the early writers, navigators, and explorers relating to the Atlantic coast of North America. After giving comparisons of the old with the new and corrected latitudes of a considerable number of places, he sums up his conclusions that the early latitudes are generally trustworthy to within a single degree; that the minutes or fractions of degrees as set down by writers anterior to the middle of the eighteenth century are never to be relied upon, and are never correct, except by accident; and that the annotations of commentators upon the latitudes recorded in the journals of our early navigators and explorers, in all cases in which they attempt to identify places within the limit of one degree by the latitude alone, can not properly be cited as authority. The sources of the errors of latitude to which attention is thus directed are not far to seek. The instruments possessed by the earlier navigators were of the rudest and coarsest character. They were graduated in degrees only, of which each degree occupied but about one tenth of an inch of space, and the attempt to subdivide this space into sixty parts, for minutes, would have been impossible if it had been made. So, putting down the fractions of degrees, or minutes, was an absolute and sheer guess. In the old journals the minutes are usually written in fractions of a degree, as one fourth, one third, one half, two thirds, or three fourths, and sometimes translated into minutes, and given as fifteen, twenty, thirty, forty, or forty-five minutes, but very rarely in any number of minutes not represented by these general fractions. The zodiacal ephemeris, moreover, was not graduated in minutes, and consequently inaccuracy existed as to the exact point of the sun in the zodiac at the time of taking the latitude. The tables used in connection with this instrument, moreover, were not calculated oftener than once in thirty years, so that they became obsolete long before they were put away, by reason of the precession of the equinoxes. Several other sources of error of minor importance, now always allowed for, were neglected in those days. "If the latitudes of the early navigators," the writer adds, "had been determined with as much accuracy as is attained by the observations of the present day, some interesting historical questions might have been settled, and some not very decisive controversies might have been avoided."

Word-Blindness. — M. Armaignac has described a curious case of persistent "word-blindness." The sufferer is and always has been in the full enjoyment of his intellectual faculties; he has never had any trouble in his speech or from paralysis; and he writes correctly, in a regular and elegant hand, whatever is dictated to him or whatever is his own thought; but, although his vision is perfect and normal, he can not see a single printed word or a written one, whether it be written by himself or another. He recognizes the names of the letters and figures, but can not join them objectively to form words or numbers; yet he can form words and numbers mentally if the letters or ciphers are dictated to him. M. Armaignac has advised his patient to learn to read again, beginning with the alphabet; but he finds the intellectual strain of joining the letters into words and syllables very severe.

Harvest-Time.—Every season is a harvest-time in some country on the globe. In Australia, New Zealand, Chili, and some other countries in South America, the harvest takes place in January. In India, it

begins in February and is completed in March. In Mexico, Persia, and Syria, it takes place in April; in Asia Minor, Algeria, Morocco, and parts of China and Japan, in May, and after this in California, Spain, Portugal, Italy, Greece, Sicily, and some of the southern departments of France. In July it begins in France, Austria, Hungary, Poland, Russia, and the Middle United States. The turn of Germany, Belgium, Denmark, and Holland comes in August, and of Scotland, Northern America, Sweden, and Northern Russia in September.

Obituary.—Mr. Thomas Potts James, who died in February last, was one of our oldest botanists, and was one of four—Sullivant, Austin, James, and Lesquereux—who have distinguished themselves as specialists in the mosses. He was born at Radnor, Pennsylvania, in 1803. Having been prevented by circumstances from acquiring a collegiate education, as he had intended, he settled down in Philadelphia as a druggist, pursuing science as a by-occupation. He was an active member of the leading scientific societies of the city, and an officer of many of them. He made himself familiar with the phenogamous vegetation of the neighborhood of Philadelphia, and then devoted himself to the special study of the mosses, on which he contributed several papers, including the bryological department of the report of Clarence King's exploration of the fortieth parallel. He was associated with Mr. Lesquereux in the preparation of the "Manual of North American Mosses" which Sullivant was about to prepare in connection with Lesquereux when he died. Mr. James's death leaves Mr. Lesquereux the only survivor of the four American bryologists, and imposes upon him the task of completing the "Manual."

Mr. John Scott Russell, the constructor of the steamship Great Eastern, died at Ventnor, Isle of Wight, June 8th, in the seventy-fifth year of his age. He was the son of a Scotch clergyman, and was destined for the Church, but his taste for mechanics and science led him in another direction. He was graduated from Glasgow University when sixteen years old; was appointed temporary Professor of Natural Philosophy in the University of Edinburgh in 1832; communicated to the British Association his first paper on the nature of waves and the best form of vessels in 1835; and received the gold medal of the Royal Society of Edinburgh for another paper bearing on that subject two years later. As manager of a ship-building establishment at Greenock, he built several vessels after the ideas he had worked out, and constructed the Great Eastern in 1846. He became a Secretary of the Society of Arts in 1845. In 1850 he was appointed a joint Secretary of the Commission for the promotion of the Great Exhibition of 1851, and was one of the three chiefs in the furtherance of that enterprise. His greatest engineering work was the construction of the dome of the Exhibition Building at Vienna in 1873, the largest dome in the world. His last work was the design for a high level bridge with a span of one thousand feet, to cross the Thames below London Bridge. He also built the steamer that carries railway-trains across the Lake of Constance; and he contributed many valuable papers to the literature of his profession.

NOTES.

Dr. Byron D. Halstead, of the "American Agriculturist," has published, in the report of the Secretary of the Connecticut Board of Agriculture, an important memoir on "Fungi injurious to Vegetation, with Remedies." In it he describes ergot, the potato-rot, the rust of wheat, corn-smut, the onion-smut, the apple-leaf fungus, the peach-curl fungus, the American grape-mildew, the lettuce-mildew, and the raspberry fungus.

M. Barral, Secretary of the National Agricultural Society of France, has shown recently that the beet-sugar industry is advancing steadily in Germany, but is stationary in France. A great change has taken place in the character of the apparatus used for extracting the sugar in Germany, where hydraulic and continuous presses have given way to a process of extraction by diffusion, the apparatus for which is much more simple. A similar change is going on in France, but it has made less advance there than in Germany and Austria. The relative depression of the industry in France is owing to two causes: the quality of the beet-roots, which

is inferior; and the manner of laying the taxes, which in Germany and Austria bear upon the fabrication, and stimulate it to devices to improve the yield, while in France they bear upon the consumption, and tend to discourage it.

A bark containing quinine and quinidine, and currently known as *Cuprea cinchona*, imported from Colombia, has recently had a sale in England comparable to the entire amount of the importation of cinchona-bark from all other countries. The affinities of the tree which produces it, hitherto unknown, have been traced out by M. Triana, who has found that the bark is chiefly derived from two species of *Remijia*, a genus of which no species was previously known to contain quinine. Seeds of the *Remijia* have been received, and are in cultivation at Malvern House, Sydenham. The tree is likely to prove valuable for cultivation in countries where malarial fevers abound. It grows at an elevation of from six hundred to thirty-three hundred feet above the sea, where even red cinchona will not flourish.

The census report on fire-arms and ammunition lays stress on the advantage of the "interchangeable system" of manufacturing, or the system by which any single part is made to fit into any machine of the same class, and its influence in the development of industries. Two of our great industries, agriculture and manufactures, now depend largely upon this system, which is of American origin, and has reached its greatest development in our country. Its introduction has reduced waste and effected economy in production. By it the manufacturer is able to furnish machines of all kinds at reasonable cost, repairs are made easy and cheap; and agricultural processes, by the aid of generally available machinery, have become greatly extended. One of the direct results of the system has been a great improvement in the strength, durability, and working performances of the machines made.

M. Torcapel describes a formation of basalt rich in pyroxene and very hard, and more than six hundred feet thick, at Aubenas, in Ardèche, France, under which the washings of the river Rhône have exposed a succession of beds of tufa, volcanic mud, and decomposed basalt containing teeth and bones of mammals which have been assigned by M. Gaudry to the Upper Miocene. The situation of the fossils and the superincumbence of the basalt leave no doubt that the animals to which the bones belonged were contemporaneous with the eruption and its victims. The date of the latter and that of the basaltic eruptions, the outflows of which cover a large portion of the central plateau of France, may therefore be referred to the period named. M. Gaudry remarks that these conclusions agree with those reached by M. Ramers in the Cantal.

M. L. Clemandot has given the name of tempering by compression to a new method of treating metals, particularly steel, which consists in heating the metal to a cherry-red, and then putting it under a strong pressure, and keeping it there till it is cooled.

The fifth in the series of "Saturday Lectures," in the National Museum at Washington, for 1882, was by Professor Riley, and gave "Little-Known Facts about Well-Known Animals," in the form of a popular account of the life-history of the oyster and his enemies, the star-fish, the shore-crab, the common frog, the house-fly, parasitism, the mosquito, and the earth-worm.

The report of the census shows that, in the whole United States, 14,462,431 acres of land are devoted to the cultivation of cotton, and that the total product of the country is 5,176,414 bales, or $\frac{40}{100}$ of a bale per acre; Georgia gives the largest extent of land to the cultivation of the staple, 2,617,138 acres; Mississippi produces the largest quantity, 955,808 bales; and Louisiana gives the largest return per acre, 0·59 bale.

Mr. William Morris Davis has made, in "Appalachia," an interesting study of "The Little Mountains east of the Catskills." These mountains, which rise only one or two hundred feet above the plain, and are about two miles wide, have a complicated structure and "a charmingly picturesque surface, and in tracing out their continual changes one encounters problems of great variety and beauty. The belt they occupy "is not great in quantity but very varied in quality." Their rocks, of the Hudson River and Lower Helderberg groups, are adorned with numerous fossils; and they afford examples of the six types of surface form as determined by folded, stratified rocks; both mountains and valleys of monoclinal, anticlinal, and synclinal structure. The whole system exhibits the Appalachian character of increase of variety and abruptness of change from east to west.

The United States produces, according to the reports of the census, 44,113,495 bushels of barley, 11,817,327 of buckwheat, 1,754,861,535 of Indian corn, 407,859,999 of oats, 19,831,595 of rye, and 459,479,505 of wheat. Of the several States, California produces the most barley, 12,579,561 bushels; New York the most buckwheat, 4,461,200 bushels; Illinois the most corn (325,792,481 bushels), oats (63,189,200 bushels), and wheat (51,110,502 bushels); and Pennsylvania the most rye, 3,683,621 bushels.

THOMAS SAY.

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ELECTRIC AND GAS ILLUMINATION.

By C. M. LUNGREN.

THE period of contest and denial over the question of the possibility of producing a light of low intensity by means of electricity, that would be suitable for the general purposes of interior lighting, has about drawn to a close. It is now pretty generally conceded—what there has never been any reason for denying—that the known laws of electric transmission interpose no bar to the successful solution of the problem, but that the difficulties in the way are solely of a practical kind. And it is, further, quite generally agreed that these practical difficulties have been for the most part resolved, and the question reduced down to one of cost simply; and, while a good deal of discussion has taken place upon this point, but little has been written that will enable the general public to form a judgment upon the subject, and arrive at a trustworthy opinion of the relative cost of it and gas under actual commercial conditions.

In estimating the relative cost of the two illuminants, it has been common to compare simply the cost of the materials consumed in their production, or, when the cost of the apparatus necessary to generate the electricity has been taken into account, this has usually been upon the basis of a limited production, and, to this extent, unfair to electricity. A comparison, to be of any value, should be between plants of a size sufficient to reduce the cost to the lowest point at which it can be commercially maintained, and should include all of the items entering into it. The attempt has been made, in the following pages, to institute such a comparison, and present the facts in the case as they are, so far as they can be obtained. The comparison is upon the basis of works capable of producing a million feet a day, as, in such works, gas can be made as cheaply as in any that are

larger. The figures for the electric plant are based upon the work of Mr. Edison, as he is the only one who has so far made any attempt to put in an electric plant upon an industrial scale. And, for that reason further, only his system of distribution is considered, though it may be a question whether it is the one which will prove most satisfactory in practice. An objection to it of considerable force in the opinion of some, is, the difficulty of handling engines and boilers with sufficient rapidity to meet great and sudden variations of demand, such as not unfrequently occur during the seasons of the year in which the weather is changeable. The variation that experience has shown takes place at different periods of the day can be met readily enough. On this account, and on account of the greater freedom secured in the matter of working various pieces of apparatus without interference, it would seem that the system of distribution which includes a storage-battery would be preferable, and may, perhaps, become the final form adopted in electric installations. It can not well enter into the present calculation, however, as there are no data with reference to the first cost and depreciation available, and because the present secondary batteries do not seem to have yet reached a satisfactory commercial form.

The cost of such a plant for coal-gas will vary in this country from $2,500 to $4,000 for each million feet of the yearly make, but $3,000 may be taken as a fair average. Owing to the great variability in the demand for light at different seasons of the year, a gas-works of this size will be called upon to furnish but 200,000,000 instead of 365,000,000 feet a year. The plant will therefore cost $600,000. Of this, $250,000 may be taken as the cost of the mains, which, in average conditions, will have, for a works of this size, a total length of fifty miles, covering a district of about three square miles. To compare an electric with a gas plant, it is necessary to know the number of five-foot burners that will be maintained at the time of greatest consumption, as on this depend both the amount of horse-power required and the size of the mains to transmit the current.

The variation in the demand for light from hour to hour, as it would occur in average conditions on a bright December day, is exhibited in the following table, in percentages of the total make for the twenty-four hours:

7– 8 A. M.	$1\frac{1}{2}$ per cent.	7– 8 P. M.	12 per cent.
8– 9 "	$\frac{1}{2}$ "	8– 9 "	12 "
9–10 "	$\frac{1}{2}$ "	9–10 "	10 "
10–11 "	$\frac{1}{2}$ "	10–11 "	6 "
11–12 "	$\frac{1}{2}$ "	11–12 "	5 "
12– 1 P. M.	$\frac{1}{2}$ "	12– 1 A. M.	$1\frac{7}{10}$ "
1– 2 "	$\frac{1}{2}$ "	1– 2 "	$1\frac{7}{10}$ "
2– 3 "	$\frac{1}{2}$ "	2– 3 "	$1\frac{7}{10}$ "
3– 4 "	$\frac{1}{2}$ "	3– 4 "	$1\frac{7}{10}$ "
4– 5 "	$7\frac{1}{2}$ "	4– 5 "	$1\frac{7}{10}$ "
5– 6 "	16 to 20 "	5– 6 "	$1\frac{6}{10}$ "
6– 7 "	14 "	6– 7 "	$1\frac{7}{10}$ "

This shows the time of greatest consumption to be between the hours of five and six, and the demand as high as twenty per cent of the entire daily make. In the case of the plant under consideration, the maximum number of burners that will have to be maintained at any one time is therefore 40,000.

Before proceeding to estimate the cost of the plant to generate and distribute electricity sufficient to maintain this number of burners, a few words descriptive of Mr. Edison's system will be desirable, especially as there appears to be considerable misapprehension on the subject. The distribution is what is known as in multiple arc—that is, the lamps are placed upon cross-wires between the conductors. Imagine a ladder erected upon an ordinary railway, so that it stands across the track, each foot resting upon one of the rails. Then these rails will represent the outgoing and returning street-conductors ; the side-bars of the ladder, the house-conductors ; and each rung, a lamp. The dynamo-machines generating the current are arranged in exactly the same way with regard to the circuit, all the positive poles being joined to one main conductor, and all the negative ones to the other. The arrangement is what is known, in the case of electric batteries, as coupling for quantity, as opposed to coupling for intensity, and is similar to that of a number of pumps discharging water into a common main. This disposition of the electric-producing apparatus has the important advantage that the reserve plant, to meet contingencies, needs to be but a fraction of the total one ; while, if each machine supplied an independent circuit, the plant would have to be in duplicate. As is well known, the steam-engines driving the dynamos are coupled directly to the machines, without the intervention of belts or gearing, the combination being termed the steam-dynamo.

The street-mains consist of wrought-iron tubes about two inches in diameter, containing two half-round copper rods imbedded in an insulating resinous cement. A main of this kind is carried continuously around each city block. At the intersections of the streets the conductors are brought together and joined to a main somewhat larger, termed a feeder, which supplies the current to these four blocks. It will thus be seen that the system of mains and the mode of production of the electricity are as readily capable of expansion to meet increased business as in the case of gas. The mains can be tapped anywhere for new consumers, and to meet this increased demand it is only necessary to run a feeder to the place of enlarged consumption, and increase the producing plant sufficiently.

What, then, will be the cost of such an electric plant to do the same amount of lighting as the above gas plant? If we take eight sixteen-candle lamps, maintained throughout the whole system for each actual horse-power applied to the dynamo-machine, engines with a normal capacity of five thousand horse-power will be required to sustain the maximum number of burners. This will include the re-

serve plant, as engines of a normal capacity of forty-two hundred can readily be forced to five thousand horse, or twenty per cent, to meet this extreme demand, and, with the generators arranged after Mr. Edison's plan, this per cent is an ample reserve. The maximum demand can, of course, be met either by forcing, or by running the entire plant at its normal rate, and forcing only in case of accident. To cover a district of three square miles, two distributing stations will be sufficient. The steam-dynamos may be taken as of two hundred horse each, working normally. The present steam-dynamos are of but one hundred and twenty-five horse, but they can be made two hundred horse with but slight increase of cost, which Mr. Edison contemplates doing in future installations. This will give thirteen steam-dynamos to one station and twelve to the other. These may each be placed at $8,000, making a total for the two stations of $200,000. That this is a sufficient allowance will be evident upon considering the machines in detail. There are first the two hundred horse-power engines. No one will question that these can be obtained by a large buyer at $18 per horse-power, or $3,600 each.* This leaves $4,400 to cover the cost of the dynamo. The material in these, as now being constructed, is as follows :

Iron (wrought and cast)............	40,700	pounds at	3½	cents	=	$1,425 00
Zinc (cast)......................	680	"	6	"	=	40 80
Copper	3,440	"	28	"	=	963 20
	44,820					$2,429 00

This leaves $2,071 for the cost of construction, which will be recognized as more than enough, when it is remembered that the cost of the iron as above given includes its shaping, and that the copper on the armature is in the form of bars and disks, which, with suitable tools, can be expeditiously constructed.

Adding twenty-five per cent to the cost of material for the 200-horse machine, there is still left $1,364 to be expended in construction. It seems to me, therefore, that $8,000 is a safe estimate of the cost of such steam-dynamos. Regarding the boilers, the sectional or water-tube boiler, on account of its freedom from dangerous explosions, the smaller space occupied by it, its higher efficiency, and less cost for repairs, is in every way the best suited for a purpose of this kind. Such a boiler set ready for use, including stack and apparatus for handling coal and firing, will cost $20 per horse-power. The total boilers would therefore cost $100,000, making the entire producing portion of the plant, exclusive of real estate, $300,000.

As the Edison mains are now being laid, they will transmit a cur-

* Mr. Edison informs me that engines of 200 indicated horse-power are being purchased by him for $1,750 each, delivered in New York. This estimate is, therefore, much too high, but, as the comparison of plant in the text is based upon it, I have thought it best to let it stand, and point out the needed correction here.

rent sufficient to maintain from sixteen thousand to eighteen thousand sixteen-candle lamps. Taking the former figure, this is one and a quarter mile per 1,000 lamps. Basing the calculation for mains upon this mileage and the size of the present mains, the same number of miles of electric mains would be required as for gas. The present conductors are, as stated, in the form of half-round copper rods, of varying sizes, diminishing of course as they proceed from the station. They are, however, equivalent to round rods with a uniform diameter of one half inch. Such rods weigh $\frac{755}{1000}$ of a pound per foot, and 3986·4 pounds per mile, costing, at 28 cents per pound, $1,116 per mile. As there are two rods in each main, the cost per mile for copper would be $2,232. To this must be added $1,200 per mile for wrought-iron tube, boxes at the joints between the mains and house-wires, and insulating material, and $1,000 per mile for laying, making the total cost of the main per mile, laid ready for use, $4,432. Four fifths of the mains would be of this size, the other fifth being feeders equivalent to round rods three fourths of an inch in diameter. These latter weigh 1·69 pound per foot, and would therefore cost $2,340 per mile, and, taking the cost of inclosing tube, insulation, and laying the same as above, their total cost per mile would be $7,196. The total cost of the mains, forty miles at $4,432 per mile, and ten miles at $7,196 per mile, would therefore amount to the same as the gas-mains, viz., $250,000. If real estate be added at $50,000, which in most cities requiring this size of plant would be ample, the total cost of the electric plant would be the same as one for gas.*

The elements entering into the cost of the light to the company furnishing it are, in each case, the interest on the investment, depreciation, or the amount spent each year in keeping the property in good condition, the labor of all kinds—in the manufacture, distribution, and management—and lastly the cost of the materials used in its production. In the case of gas but a few of these items as they occur in American works are obtainable, so that recourse must be had to the published reports of foreign companies, and the like items estimated for this country. Of these, the reports of the London companies as analyzed by Mr. Field will best serve for the purpose of the present comparison.† Taking first the item of depreciation, we find that for the four metropolitan companies this was, for the year 1880, on the producing portion of the plant 9·86 cents per 1,000 feet of gas sold, or about five and a half per cent on the cost of this part of the plant as it has been taken in this paper. Calling this ten cents a thousand

* While this estimate seems to me not far from the expenditure that would be actually required for this size of plant, it should be stated that it is lower than any of those given by the electrical experts examined by the select committee of the House of Commons in its consideration of the Electric Lighting Bill.

† Having been unable to obtain a copy of Mr. Field's "Annual," I have taken the figures as quoted from this for the year 1880 by Mr. Dowson, in a recent lecture before the Society of Arts.

feet, we have \$20,000 a year as the expenditure under this head, which is probably well within the actual figures of most American works. In the case of the electric plant four per cent is a sufficient allowance for the same item, which gives a yearly charge of \$12,000, and a cost of six cents per 1,000 feet.

Depreciation of this part of the plant varies but little with different works, as the conditions upon which it depends are relatively constant, but that of the mains is, on the other hand, exceedingly variable. In a dry, open soil, gas-mains will last a great length of time, and even when they become entirely rusted through they will still continue efficient if undisturbed. They do not, however, remain undisturbed, so that in the most favorable conditions some expenditure is necessary to keep them in working condition. We shall probably not be far wrong if we take this at two per cent of the entire cost of the mains, which includes, of course, that of laying them. This item then becomes in the case of our gas plant \$5,000 per year, and $2\frac{1}{2}$ cents per 1,000 feet. In the case of the electric mains, this percentage must be reckoned only upon their cost, exclusive of the copper, as this latter is practically indestructible, and can be used again and again. The amount upon which to reckon the two per cent depreciation is therefore \$2,200×50 =\$110,000, and the yearly charge \$2,200, which gives 1·1 cent per 1,000 feet. The interest on the investment is the same in each case, and amounts to \$24,000 a year, at four per cent, and to 12 cents per 1,000 feet. These items include all that are properly chargeable to the expense account of the plant save taxes, which would be about the same in each case, and which may be neglected for the present. The plant account, then, stands, in the two cases, for each thousand feet or its equivalent:

	Gas.	Electricity.
Interest	12·	12·
Depreciation of producing works	10·	6·
" of mains	2·5	1·1
Total	24·5	19·1
	19·1	
Balance in favor of electricity	5·4	

The items entering into the cost of coal-gas are, exclusive of management, rent and taxes, etc., the cost of coal, of manufacturing, and of distribution. Taking the last first, we find 4·4 cents per 1,000 feet as the cost of this item for the four metropolitan companies. Putting this at 5 cents for American works, and deducting from this $2\frac{1}{2}$ cents for the depreciation of mains, which is included in this charge, there is left $2\frac{1}{2}$ cents for the cost of the labor of inspection of meters, etc., which constitutes the charge of distribution, and which would be about the same in both systems.

As the depreciation of the mains is not given separately, this item is liable to error, due to a wrong estimate of such depreciation, but, as it affects both systems similarly, it will not vitiate the results. Under

manufacturing, the English report includes purifying, salaries, the wages for carbonizing, and wear and tear, which latter item has already been carried to the plant account. The first of these amounts to 1·82 cent; the second ·82 of a cent, and the third to 7·16 cents, making a total of 9·8 cents per 1,000 feet. This is probably much below the actual amount paid for these items in American works, but I am assured on excellent authority that, in works constructed after the best modern models, purification should cost the gas company nothing, and that all labor in the manufacturing department should be covered by an outlay equivalent to one man's wages ($2.50 per day) for each 40,000 feet of gas made per day. As the same amount of labor would have to be paid for each day in the year as on the days of greatest demand, this would amount, for a daily make of 1,000,000 feet, to 25 men whose wages at $65 per month ($26 \times 2\frac{1}{2}$) would be $19,500 * a year, or $9\frac{3}{4}$ cents per 1,000 feet of the actual make. Including the cost of purification, and calling the amount 12 cents, we shall not be far wrong, or at least shall not exceed the actual outlay in the average works of this size. In the case of electricity the labor required at each station would be:

One chief-engineer	$125	per month.
Three assistants (at $75)	225	"
Five firemen (at $60)	300	"
Total	$650	

—making $15,600 a year for the whole manufacturing plant, and 7·8 cents per 1,000 feet. To this may be added $1\frac{1}{5}$ cent to cover salary of electrician and incidental labor, bringing the item up to 9 cents.

There remains to be considered the cost of the coal in the case of gas, and the expense of running the engines in the case of electricity. The cost of coal per 1,000 feet of gas made was, in the case of the London companies, $36\frac{86}{100}$ cents, corresponding to $3.51 per ton, the make of gas being for this amount of coal 9,529 feet. This was offset by the sale of residuals, as below:

Coke and breeze	11·16	cents.
Tar and products	7·18	"
Ammonia and products	5·72	"
Total	24·06	"

—which leaves 12·8 cents as the net cost of the coal.

Compared with foreign companies, both in England and on the Continent, but very little is done with the residual products in this country, and the amounts received vary greatly between different works. Reliable data on this point can not be obtained, but under the most favorable conditions this item can not be taken as amounting to

* The engineer furnishing the information on which this statement is based informs me that this should be $12,500, or $2.50 per 40,000 feet of the actual yearly, instead of the maximum daily, make. This would reduce the item $9\frac{3}{4}$ cents to $6\frac{1}{4}$ cents per 1,000 feet.

more than one half the cost of the coal, while with most works it is probably inconsiderable. The average price of the coal used may be placed at $4.50 a ton, and the amount of gas produced 10,000 feet, making the cost 45 cents per 1,000 feet. This make of gas can hardly be maintained with a production of residuals equal to one half the cost of the coal, but, assuming that it is, the cost of the coal becomes $22\frac{1}{2}$ cents per 1,000 feet.

In the foregoing estimate of the electric plant, it has been assumed that eight lamps could be maintained throughout the entire distributive system for each actual horse-power expended upon the pulley of the dynamo-machine. That this is entirely feasible has been proved by careful tests made by experts in no way interested in any of the lamps, and their results can therefore be accepted without question. For such a use as electric lighting, the cost of a horse-power may safely be taken as not above the best results hitherto obtained in practice. In general manufacturing, the item of power, while important, is not sufficiently so to demand that constant and great care necessary to obtain the very best results, and hence few engines and boilers yield in practice the same results as in special tests. With electric-light companies, this item, on the contrary, is vital, and we may confidently expect to see them in time obtaining their power at a considerably less cost than is now common. Mr. Edison finds as a matter of fact confirmed by several months' test at Menlo Park, that he is able to maintain a horse-power an hour with five pounds of slack (one third pea and two thirds dust), costing $2.45 a ton. For the purpose of the present comparison, however, it is best to make a liberal allowance, and take for a 200-horse-power engine a consumption of four pounds of coal an hour, the coal costing $4.50 per ton of 2,240 pounds, delivered. A horse-power will then cost $\frac{8}{10}$ of a cent an hour, and we may rightly abate our liberality sufficiently to include in this the cost of the oil for lubricating the engine and dynamo.

The maintenance for an hour of 200 electric burners, the equivalent of the 1,000 feet of gas, will therefore cost 20 cents, as against $22\frac{1}{2}$ cents for the gas.

Summing up the results so far obtained, the two accounts stand as follows:

Plant Account.	Per 1,000 Feet. Gas.		Electricity.	
Interest	12·		12·	
Depreciation of producing works	10·		6·	
Depreciation of mains	2·5		1·1	
		24·5		19·1
Manufacturing expenses:				
Labor	12·		9·	
Coal	22·5		20·	
		34·5		29·
Working expenses:				
Distribution		2·5		2·5
Total		61·5		50·6

Under this last heading there should be added rent and taxes, management, law charges, bad debts, and various incidentals. These can not be separately arrived at with any closeness, but they may be taken in the lump as about the same part of the total charges as in the case of the London companies, which is 16 per cent, exclusive of the interest on investment. This in the present case would be 9·4 cents per 1,000, bringing the total cost per 1,000 up to 71 cents with gas and 60 cents with electricity.

The promoters of the electric light would probably demur to this statement, so far as rent and taxes are concerned, as they insist upon the much smaller real estate required with the electric than with a gas plant. This difference does not, however, seem to me sufficient to be of any practical moment, as the real estate in the case of electricity is in the district supplied, where the price of land is relatively high, while the gas companies can readily place their works in such locality as to compensate in lowered land value for the greater amount required. Gas companies can, moreover, build within much smaller limits than usual when for any reason it is desirable, and closely approach the space requisite for an electric installation.

An item of considerable amount which has been omitted from the estimate for electricity is the cost of the renewal of the lamps. With the general introduction of incandescent electric lighting, this is a charge which would fall directly upon the consumer, but it is one which would steadily diminish with improvement in lamps. Assuming, however, that it is a legitimate charge upon the company supplying the light, the item amounts to 10 cents per 1,000, if the lamps have a life of 600* hours and cost 30 cents. This brings the electric account up to 70 cents per 1,000.

So far as coal-gas is concerned, then, these figures show a slight advantage in favor of electricity, and while they are only approximative they are near enough to the truth, I think, to represent the actual relation of the two illuminants. While very much doubtless remains to be done in the improvement of coal-gas manufacture, it does not seem probable that this will affect its cost of production to the same extent as future improvements of electric apparatus may be expected to decrease that of the electric light. Looking closely at the two accounts, it does not seem probable that the item relative to plant will be materially lessened in the future. The cost of the plant has already been taken at a figure very near the lower limit, so near that the substitution of this in its place would make a difference in the yearly plant account of but 2½ cents per 1,000. We may, on the other hand, expect improvements to largely reduce the cost of the electric plant. On Mr. Edison's system of distribution, the size of the conductors varies inversely as the resistance of the lamps, so that they may be

* I am informed by Mr. Edison that the average life of the lamps is now 900 hours, including 3 per cent breakage in handling.

materially reduced if the resistance of these latter can be increased; while any improvements affecting the number of lamps per horse-power diminishes both the interest account by reducing the plant and the actual cost of production.

How far coal-gas can go in a reduction of the cost of production it is difficult to say, but I think the lower limit may safely be taken at the point at which the sale of residuals pays for the coal. Both of these items—cost of coal and prices of residuals—are practically beyond the control of a gas company. The coal is already purchased in the open market at the lowest figures at which it can be obtained, and the market for residuals depends chiefly upon the development of chemical industries, which can hardly be hastened by the action of a gas company. This market is a steadily growing one, and it is not impossible that the residuals will in time pay for the coal, though it is hardly probable. The items of labor and distribution can not probably undergo any considerable reduction. The limit, then, below which it does not appear that there is any probability of coal-gas falling in this country is 46 cents per 1,000, which is a figure that may be reached by electricity without assuming anything less probable than the above supposition respecting gas. It is only necessary to get ten lamps per horse-power, and produce the latter with three pounds of coal an hour, to bring the cost down to 47 cents, exclusive of the lamps.

As a present competitor, however, what is known as water-gas—gas produced by the decomposition of steam in the presence of coal or oil—appears to be the more formidable. This mode of gas-manufacture has the advantage of coal-gas in a lessened cost of the producing plant, a smaller labor account, and a decreased depreciation of the generating apparatus. Its successful competition with coal-gas ultimately depends upon what the latter can make of its residuals, as there is no offset of this kind in its case, but with present conditions it can go below it. The producing portion of the plant costs but little more than half that for coal-gas, while the labor is about a third, and depreciation but slightly more than this. A sixteen-candle gas will require three gallons of oil per 1,000 feet, and can be made with oil at 5 cents a gallon and coal at $4.50 a ton, at an expenditure of 28 cents per 1,000 feet for materials. The total cost will not exceed 60 cents.

Such, then, appears to be the relation of these two agents on the basis of illumination solely, but it must not be forgotten that the amount of light which each plant can furnish does not represent the actual relative capacity of the two. The electric plant can be run not only four hours a day for light, but any further number of hours for power, without any increase of the machines. The gas-plant, on the other hand, would have to be increased, to furnish both power and light. That this advantage of electricity is liable to be a very important one will hardly be questioned, when the extent of the field open to electro-motors is borne in mind.

On these figures the cost of electricity is near enough to that of gas to enable it to offer a very substantial competition, and one which may be expected to grow stronger with increased experience and future improvements. That under the stimulus of this competition considerable improvement will be made in lighting by gas seems very probable. Already it has been shown that in the matter of burners there is a wide field for invention, and that the results now usually obtained are much under what are possible. With the high-power burners of Siemens, the illumination obtained from sixteen-candle gas has been more than doubled, and in others it has been carried up to from five to five and a half candles per foot. How suitable burners yielding such a great increase of light will be for the general purposes of lighting, and whether they can with advantage displace the simple flat tip, remains to be seen, but the present indications are that it is chiefly through the use of improved burners that gas must endeavor to resist the assaults of the incandescent light. Competition on the basis of a gas of higher illuminating power simply, without a resort to improved burners, does not seem very promising. The recently published report of the sub-commission, appointed to test the incandescent lamps at the Paris Exhibition, of which Mr. Crookes was a member, shows that a thirty-two-candle lamp can be maintained with an increase of from 28 to 37 per cent of the power required to sustain one of sixteen candles, while with gas such an increase of illumination will require an additional expense of fully 50 per cent of the cost of one of the lower candle-power. This is so with the Lowe gas, with which three gallons of oil are sufficient to give sixteen candles, but six are required for thirty-two, and it is not probable that coal-gas can be enriched any cheaper. Whether the limit to progress in gas-lighting—both in the matter of improvement of manufacture and burners—is sufficiently far off to give gas unquestioned possession of the field of lighting or not, the result can alone determine. But, if the figures presented in this paper can be at all relied upon, they show that gas-manufacturers and those interested in gas property will do well not to underrate the strength in their own domain of this rising industrial power.

LONGEVITY.

By FELIX L. OSWALD, M. D.

DURING his last expedition to Central Asia, Professor Vambéry managed to interview the Emir of Samarcand—a sort of Mohammedan prince-cardinal and primate of the Eastern Sunnites. As Imam of the local lyçeum the Emir appeared to take a natural interest in the progress of European science, but, when his guest expatiated on

the material prosperity of the Western Giaours, he interrupted him with a less expected question.

"The happiest people on earth, you call them? What age do they generally attain to?" Vambéry seems to have returned an evasive reply, though he admits that the query was not altogether irrelevant, at least from the stand-point of an Oriental who values existence for its own sake. But, even in the less unpretending West, longevity is not a bad criterion of happiness. Misfortune kills; Nature takes care to shorten a life of misery—for reasons of her own, too, for, in a somewhat recondite (but here essential) sense, the survival of the happiest is also the survival of the fittest. The progress of knowledge tends to circumscribe the realm of accident, and with it the belief in the existence of unmerited evils. In spite of prenatal influences and unprecalculable mishaps, the management of the individual is the most important factor in the sum total of weal or woe. If we could see ourselves as Omniscience sees us, we would probably recognize our worst troubles as the work of our own hands, and we thus recognize them now with sufficient clearness to be half ashamed of them. Most men nowadays dislike to confess their bad luck. We have ceased to ascribe diseases to the malice of capricious demons, and even in Spain the commander of a beaten army would hesitate to plead astrological excuses. Polycrates held that a plucky man can bias the stars, and the popular worship of success may be founded on an instinctive perception of a similar truth. Sultan Achmed went too far in his habit of strangling his defeated pashas, but the world in general agrees with him that there must be something wrong about a generally unsuccessful man. After two or three decided defeats the partisans of a popular leader will give him up for lost, and after a series of disasters the damaged man himself generally begins to share their opinion and loses heart, or, as the ancients expressed it, admits the decree of fate—i. e., his own inability to prevail in the struggle for existence; and it is curious how swiftly a physical collapse often follows upon such a giving way of the moral supports. The storms of every political, social, and financial crisis extinguish hundreds of life-flames; lost hope is a fatal (though a silent and sometimes an unconfessed and unsuspected) disease. Good luck, on the other hand, tends to prolong life; the longevity of pensioners and sinecurists is almost proverbial, and there are men who continue to live in defiance of all biological probabilities, merely because existence somehow or other has become desirable, as a liberal supply of external oxygen will nourish a lamp in default of the inner oil. At the beginning of the Franco-Prussian War, King William and his chancellor and staff-officers were already gray-headed veterans, and it is no accident that they are all alive yet; while nearly all the ministers and marshals of the exploded empire have followed their leader—"weary of life and tired of buttoning and unbuttoning," as a captain of H. M. S. explained his suicide.

The votes that killed Cavour and Disraeli probably revived La Marmora and Gladstone. Success is a panacea; a series of long-lived rulers will generally be found to coincide with an era of national triumphs, and a general increase of longevity with a period of material progress, industrial development, good crops, etc., for, when "living" is cheap, one man's success does not necessarily imply the short-coming of his neighbor.

But, as Ludwig Börne says, "to be happy is one of the cardinal virtues"—there is such a thing as a gift of supporting vitality on an accident-proof fund of good humor, a Mark-Tapley-like disposition to exult in the disregard, or, at least, in the defiance, of bad-luck. In stress of circumstances, Hamlet's alternative may often depend upon the possession of this accomplishment, for I believe that it is one of the talents which can be cultivated. Not all men can attain to the philosophical eminence of Francis Fénelon, who valued gloomy days as a foil to brighter ones; but a step in the right direction is a resolute contempt of trifling adversities, which leads to the habit of distinguishing life from its incidents, the pilgrimage from the way-side vicissitudes, and can be most easily acquired by keeping an ultimate goal in view—not a supramundane one necessarily, but something elevated enough to aid us in overlooking the base annoyances which beset all but the loneliest by-ways of modern life. This devotion to a nobler and enduring, or even a permanently interesting, object—a mere hobby, in fact—serves to enhance the value of life, and explains the success of many survivors under apparently hopeless difficulties, the victory of competitors handicapped with disease, poverty, and deficient education; they support a cause which supports them in return; they live upon as well as for a principle. Hence the apparent paradox of the longevity of busybodies, of men who seem to burn the fuel of life at an extravagant rate. Xenophon, Cardinal Richelieu, Ximenes, Benjamin Franklin, and Frederick the Great, were probably the busiest men of their respective nations, gallop-riders on a road where others kept the even tenor of their way, but they bestrode their hobbies and managed both to outride and outlive their competitors.

It is, indeed, a mistake to suppose that the tranquillity, *per se*, of a man's life tends to prolong its duration; and the longevity of stagnant villages and country parsons proves only how infinitely *health* outweighs all other means of happiness. The peasants of Southern Russia live almost as frugally as the Hebrew patriarchs, on milk, bread, and honey, with a bit of cheese now and then, or a drop of hydromel (half-fermented honey-water); their climate is dry and favorable to perennial out-door life, and in spite of official tyranny, war, and rumors of war, feudalism, and outrageous over-taxation, they outlive the free-born British yeoman, with his strong ales and daily beefsteaks. But the coincidence of dietetic and administrative abuses cuts the thread of life with a two-edged knife, and in Northern Russia the average

duration of life is ten years less than among the equally intemperate but less misgoverned natives of Northern Germany, and almost twenty years less than in the equally despotic but less poison-cursed territories of the Shah.

Historically, too, the lowest ebb of human happiness coincides with that of human longevity. The ancient Greeks outlived us by about thirty years, but even our northern Russians would outlive the nations of the Christian middle ages, when common sense was a capital crime, the suppression of all natural instincts the chief aim of education, and the invention of new instruments of torture the only flourishing branch of industry. The Western pessimists dislike to confess the main object of their religion; but their first exemplar, Buddha Nepaulensis, did not hesitate to define it as the mortification of all earthly desires—in other words, the shortening of life by all possible means, excepting the resort to the summary and, therefore, more desirable methods of direct suicide.

The depreciation of Nature, which formed the constant theme of the orthodox preachers, may have had something to do with the unparalleled destructiveness of mediæval epidemics; if life was a curse and death the highest gain, the converts of such dogmas must have yielded to Siva with Hindoo-like apathy, while, on the other hand, it is a well-established fact that the mere determination to live has often turned the scales in the crisis of an apparently hopeless disease. During the Grecian Revolution of 1821, Edward Trelawney survived a load of buckshot because he "felt that he had no right to die," and mothers with a houseful of sick children have frequently resisted the virus of a contagious fever. Mahmed Kasim, the first Arabian conqueror of Hindostan, was infected with the pest by the messenger of a rajah who had adopted that method of freeing his country from the invaders, and, in spite of all remedies, a number of Mahmed's companions died before the end of the week. But Mahmed himself "conquered the disease as he had conquered the rajahs"—recovered by sheer will-force, and continued the campaign on the seventh day after the arrival of the plague-bearer.

In the century of Trajan, the Thessalian mountaineers were the macrobiotes, the long-livers, *par excellence*, of the Roman Empire; the natives of Asia Minor, with her over-populated islands and luxurious cities, the most short-lived. Time has since wrought strange changes in the land of the Ephesians; the wealthy cities have disappeared, and, with the single exception of her North-Persian neighbors, the Levanters are now the longest-lived race on earth. Next come the Turks, Greeks, Arabs, Hindoos, and southern Russians; next to these, and long before any West Europeans, the present inhabitants of the United States, for the advantages of a golden age like ours more than counteract such things as pork-fritters and strawberry-shortcakes. Among the separate States, North Carolina and Vermont hold the highest rank; Louisiana and New Jersey the lowest, topographi-

cally as well as biologically. As a rule, highlanders outlive their lowland neighbors, country people the city folks, and among the cities of the Caucasian nations sea-port towns without swamps are the most salubrious. New York is the healthiest large city in America; St. Petersburg, in spite of her high latitude, the unhealthiest of all cities whatever, taking the longevity of the natives as a criterion, for the inclusion of foreign residents would give the highest death-rate to Singapore or Vera Cruz. The Neva swamps breed fever and rheumatism, diphtheria and consumption, turn about, and in co-operation with the marasmus of bureaucracy and political espionage. But what makes Munich such a peculiarly unhealthy place? It must be lager-beer, or else the tedium of Bavarian orthodoxy and Wagner's operas—the mania of the past combined with the "music of the future"—for under the same latitude merry Paris reconciles fast-living with long-living enough to yield to no first-class city except New York. The burghers of Vienna shorten their lives with greasy made-dishes, and the Berliners with fell schnapps and a still fiercer struggle for existence—twelve hundred thousand eupeptic bipeds, surrounded by sand-hills, and living on their wits and on each other.

London holds about the medium between New York and St. Petersburg, but should not be mentioned in the same class with other towns, since her populace has expanded into a nation, distributed over fifteen or sixteen towns and half a hundred villages. The business part of the great brick wilderness, divested of its oases and outlying garden regions, would probably prove to be the richest harvest-field of Death, for coal-smoke and red-hot competition are unfavorable to longevity, and the *mens æqua in arduis* has ceased to be an Anglo-Saxon characteristic.

The cities of Italy, Spain, and Portugal have become parasites upon the starving country population; strongholds of pampered priests and titled sinecurists; but, with all his freedom from worldly cares, the *gordo sanducho*, the clerical glutton, is outlived by the rustic pariah, as a proof that the favor of Nature is better than the favor of princes:

> "How small the part that laws can cause or cure,
> Of all the ills that human hearts endure!"

—and human bodies, too; the tax-collector, with his thumb-screws, calls around once a year, but the gout every week, and dyspepsia once or twice a day. Turks and Italians inhabit the same latitude, and nearly the same kind of mountains and semitropical plains, and the remarkable physical inferiority of the Trinitarians must be ascribed to their stimulating diet and greater sensuality, for somehow or other the rustic Mussulman is a truer monogamist than his Western neighbor. In the time of Strabo the Island of Cos was noted for the general health of its inhabitants and their longevity, which some Grecian physicians attributed to the excellence of the drinking-water, and others

to the genius of Hippocrates, who had taken the islanders under his special protection. That genius must have settled in the Turkish town of Janina, where drug-stores are unknown, and indeed superfluous, as a sick person is at once suspected of wine-drinking, and takes care to conceal his condition. The town is situated at the head of a clear mountain-lake, and the longevity of the abstinent inhabitants might tempt an undertaker to indulge in the remark of Frederick the Great, at the battle of Kolin, when his grenadiers finally refused to advance: "*Ihr Hunde, wollt Ihr ewig leben?*"—(Ye hounds, are ye going to live for ever?)

Frugality, in the sense of vegetarianism, is the sometimes involuntary virtue of most Orientals, and may help neutralize their narcotics; the flesh-abhorring Hindoos attain to a surprising age, considering their *penchant* for betel-poison and their ultra-Arabian poverty. Our carnivorous red-skins are the most short-lived of all outdoor dwellers, and clearly in consequence of their diet, for in South America, too, even the inhabitants of the malarious sea-port towns survive the *gauchos*, whose *menu* is limited to three courses and one *entremet*—dried beef, fresh beef, salted beef, and beef-tallow.

Professor Schrodt, who includes horse-riding among the sedentary occupations, recommends pedestrianism as a cure for all possible diseases, since the German *Land-boten*—mail-carriers afoot—generally attain to an extreme old age, and appeals to several Grecian writers who make a similar remark in regard to the Spartan *hemerodromes.* In Prussia all government employés are pensioned after a certain term of service, and a *Land-bote* enjoys, therefore, the advantage of an insured income in conjunction with the necessity of physical exercise—bodily motion combined with ease of mind—the health-secret of the gymnosophists and the children of the wilderness.

"Woe to them that are at ease!" says Carlyle, but his anathema does not prevent the English village parson from outliving every other class of his countrymen, not excepting the British farmer, whose peace of mind can not always be reconciled with high rents and the low price of American wheat. Where agriculture is what it should be—a contract between man and Nature, in the United States, in Australia, and in some parts of Switzerland—the plow-furrow is the straightest road to longevity; in Canada, where Nature is rather a hard taskmaster, the probabilities are in favor of such half-indoor trades as carpentering and certain branches of horticulture—summer farming, as the Germans call it. Cold is an antiseptic, and the best febrifuge, but by no means a panacea, and the warmest climate on earth is out and out preferable even to the border-lands of the polar zone. The average Arab outlives the average Esquimau by twenty-five years.

The hygienic benefit of sea-voyages, too, has been amazingly exaggerated. Seafaring is not conducive to longevity; the advantage of the exercise in the rigging is more than outweighed by the effluvia

of the cockpit, by the pickle-diet, the unnatural motion, and the foul-weather misery; and, from a sanitary stand-point, the sea-air itself is hardly preferable to mountain and woodland air. The eozoön may have been a marine product, but our Pliocene ancestor was probably a forest creature.

"For what length of time would you undertake to warrant the health of a seaman?" Varnhagen asked a Dutch marine doctor. "That depends on the length of his furlough," replied the frank Hollander, and it will require centuries of reform to redeem our cities from the odium of a similar reproach. In victuals and vitality towns consume the hoarded stores of the country, and only the garden-suburbs of a few North American cities are hygienically self-supporting. Permanent in-door work is slow suicide, and between the various shop-trades and sedentary occupations the difference in this respect is only one of degree. Factories stand at the bottom of the scale, and the dust and vapor generating ones below zero; the weaver's chances to reach the average age of his species have to be expressed by a negative quantity. In France, where the tabulation of comparative statistics is carried further than anywhere else, the healthfulness of the principal town trades has been ascertained to decrease in the following order: House-building, huckstering, hot-bed gardening (florists), carpenter and brick-mason trades, street-paving, street-cleaning, sewer-cleaning, blacksmiths, artisan-smiths (silver, copper, and tin concerns), shoemaking, paper-making, glass-blowing, tailor, butcher, house-painter, baker, cook, stone-masons and lapidaries, operatives of paint and lead factories, weavers, steel-grinders—the wide difference between brick and stone masons being due to the lung-infesting dust of lapidary work, which, though an out-door occupation, is nearly as unhealthy as steel-grinding. Lead-paint makers have to alternate their work with jobs in the tin-shop, and, after all, can rarely stand it for more than fifteen years; needle-grinders generally succumb after twelve or fourteen years. The human lungs seem able to eliminate the impurities breathed by street and sewer cleaners, for, in London as well as in Paris and Marseilles, the followers of both trades rank high among the long-lived classes. Hucksters somehow manage to outlive city gardeners as well as shopkeepers; among the Hecubas of the Paris market-hall, not less than two hundred and eighteen had passed their threescore and tenth year.

Preaching, and, strange to say, pettifogging, are the healthiest of all the learned professions; their lung-exercise may have something to do with it, for lecturing-teachers outlive the "silent" teachers (dancing-masters, etc.). Physicians die early; Nature revenges herself upon her leagued adversaries, for druggists and barbers (in many parts of Europe synonymous with village quacks) are likewise short-lived; but sextons reach a good old age: there must be a mistake about the supposed danger of grave-yard effluvia.

Art still increases the value of human life, but not its length; the greatest modern masters of tune and color died in their prime, like the greatest poets; inspiration, in all its forms, would seem to be a flame that consumes the human clay more quickly than the fire of affliction—if the extreme longevity of so many of the ancient masters did not suggest a different explanation, namely, that the revelations of Nature and the tendencies of established dogmas have ceased to harmonize, and that the lovers of truth have nowadays to cross a Pontus where they must prevail against a whole sea of adverse currents, or Leander-like perish.

In the course of the last sixty or seventy years the average duration of human life has undoubtedly increased in all civilized countries, but it is not less certain that the gain of a few decades does not yet begin to offset the loss of centuries; we have saved ourselves from the abyss of mediæval unnaturalism, but we are still far from having recovered the ancient heights of vitality; the after-effects of the Buddha-poison still cramp our limbs and sadly retard our upward progress; but the tide has turned, and the main currents of the age have ceased to set deathward.

According to the demonstrations of the naturalist Camper, the normal average of our life-term should be at least ninety years. His arguments are both biological and historical, and would agree with the scriptural records, if, as Schleiermacher suggests, the Genesis-years were *seasons*, of about ninety days. The "years" of the patriarchs were certainly not *months*, for men who saw their children and children's children must have lived longer than thirty years The biological argument that in a state of nature the life of a mammal relates to the period of its growth as 6–8 to 1, would give us an average of 90–160; the southern Arab is full-grown with sixteen years, the northern Caucasian hardly before twenty. Hundreds of ancient statesmen and philosophers outlived their threescore and ten by a full decade, though we need not doubt that then, as now, metaphysics and politics were not specially conducive to longevity, nor that even by that time vices had shortened the natural average by several decades.

But there is another *a priori* argument which, from all but an ultra-pessimistic stand-point, seems almost self-sufficient in its conclusiveness. The whereabouts of new planets have been discovered by an inductive process based upon the observation of otherwise unaccountable disturbances in the orbits of other stars, and Camper's theory alone would account for an otherwise inexplicable contradiction in the economy of human life. Man's life is too short for the attainment of its highest purposes. Our season ends before its seed has time to yield a harvest; before a brave day's work is half done we are overtaken by the night, when no man can work. As the world is constituted, it takes a certain number of years for a new industry to take root and yield its first fruits; it requires a certain period for a new opinion to

penetrate the crust of society and reach the fertile subsoil of the lower strata. Before the end of that period the planter of the tree has to fertilize the soil with his own bones ; the weary tiller has to yield his plow to other hands. And the noblest plants are of such slow growth that the master of the vineyard appears to discriminate against his worthiest laborers ; nothing seems wanting to aggravate the injustice and incongruity of the existing arrangement.

But a minimum life-term of ninety years would reconcile all contradictions : two thirds of it would be enough for the adjudication of every claim, and the remaining third could be devoted to rewards or retributions. The second generation, which now can only reverse and regret the short-sighted judgment of the first, would have a chance to make amends for the injustice. Such men as Kepler, Spinoza, Dante, Milton, Bayle, Rousseau, Mirabeau, Burns, Beethoven, Paine, and Byron, would have survived the influence of their detractors, and Time, the avenger, could have answered their appeal with something better than a monument.

ANIMAL SELF-DEFENSE.

By H. L. FAIRCHILD.

A FIERCE and pitiless struggle for life in the animal world is a stern fact. All creatures are beset by dangers. The negative conditions of cold and hunger and the positive influences of nature's elements are more easily resisted than the innumerable voracious foes. Every animal is predestined food for some other animal. But self-preservation is a universal thought, and endless is the variety of ways whereby life is prolonged.

A few external organs of defense are familiar to every one—as horns, claws, teeth, stings, shells, etc. Many animals depend on weapons and muscular power, a still greater number upon keen senses and fleetness—eternal vigilance. Others rely upon intelligence, cunning, simulation, and deceit ; while stupidity, against which even the gods are powerless, may be the saving of others. Some are protected by skill in construction, some by unconscious resemblance, and a host by color, armor, and other passive means. A volume would not exhaust the subject, as there is scarcely a species of animal without some peculiarity for self-preservation.

This brief paper will only treat of defense against enemies ; and, although the subject permits of no natural classification, an arbitrary division into passive and active defense will be convenient.

A host of animals of all classes and ranks are more or less defended by a hard covering—the result of natural growth. Such defense, like other modes to be described, is strictly involuntary and passive ; and,

requiring no intelligent effort, it may be regarded as the lowest. But even in this there is unbounded variety. We will distinguish the following classes :

1. *Transformed epidermis* constitutes the armor of the lobster, insects, and hard-skinned articulates in general. Also the hair of mammals, the feathers of birds, the scales which cover most fishes, reptiles, and the legs of birds, and the plates of that lizard-like mammal, the

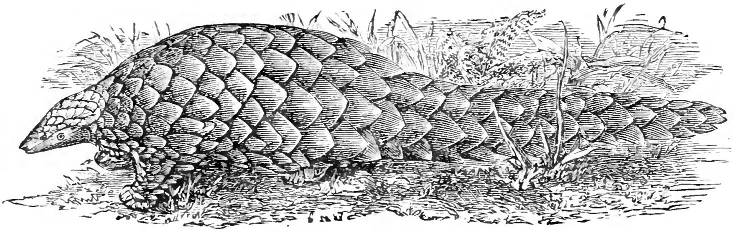

FIG. 1.—MANIS (*Manis pentadactyla*).

manis. 2. *Stony secretion* of the skin. Here belong the limy shells of mollusks, the tests of sea-urchins, star-fishes, etc. ; also those of the chalk-forming rhizopods, and the silica shells of other microscopic animals. 3. True *bony armor* produced by the skin ; as the coat-of-mail of the armadillo, and the scale-armor of the ganoid fishes, the bony pike and sturgeon, for example (also the armor of the group to which

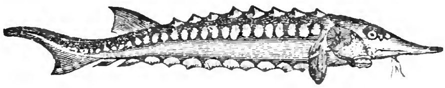

FIG. 2.—STURGEON (*Acipenser*).

belong the trunk-fishes. This sort of armor was very common among the most ancient fishes, but it has now gone quite out of fashion. The crocodile and alligator still have this bone armor in great perfection, and covered with epidermic plates—that is, they have a combination of 1 and 3. Altogether they are as well protected as any

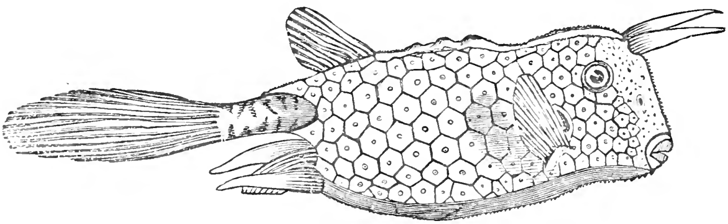

FIG. 3.—OSTRACIONTIDÆ. Horned Trunk-fish (*Ostracion cornutus*).

living creature. The armadillo has only its back covered with this bone armor, but, like the hedgehog and the manis, it can roll itself into a ball with the unprotected parts inside. 4. In the turtles the

endo- or *vertebra-skeleton*, is strangely modified and partly expanded upon the outside of the body; so it is literally true that the turtle is inside of his internal skeleton. The ribs are expanded to form the carapax, and the breast-bones to form the plastron of a solid box, within which many species can withdraw their head and limbs. But this is not all. The box is completed by the addition of numerous bony plates developed from the skin, and over all a horny epidermic

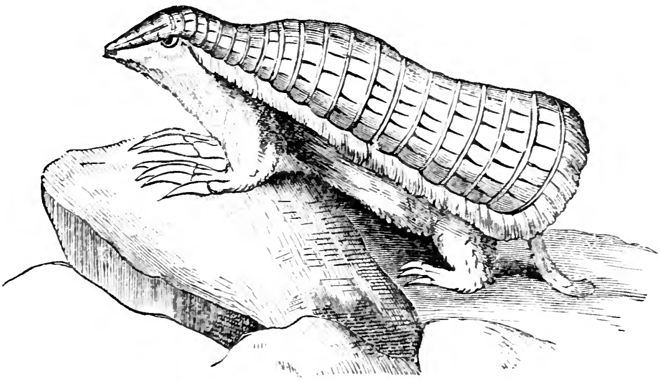

FIG. 4.—ARMADILLO (*Chlamyphorus truncatus*).

covering. The latter furnishes the beautiful and valuable tortoise-shell. Thus the armor of a turtle is a combination of 1, 3, and 4. One of the land-tortoises, the box-tortoise, deserves particular mention. The plastron, or breast-plate, of this species is divided into two movable parts hinged at a line drawn transversely or across the middle. When its head and feet are withdrawn, each end of the shell is tightly closed, so that no animal can get even a claw inside.

The skin of the rhinoceros is so very tough and thick that it defies ordinary weapons, and is said to resist soft-lead rifle-bullets.

Spines may be either (1) *epidermic* or (2) a *secretion*. The first class includes the spines of the echidna, hedgehog, and porcupine; also those of most fishes, lizards, and crabs. To the second class belong those of the globe-fishes, mollusks, rhizopods, and sea-urchins. The spines of the latter group have a remarkable structure. They are attached to the test or shell by a ball-and-socket joint and each moved by independent sets of muscles. While some species have only a very few large club-shaped spines, others have countless thousands of minute needles. The thorn-like spines of the common sea-urchin are also used in locomotion, and it has been happily said that a sea-urchin on its travels is like an animated chestnut-bur.

The hedgehog is one of the best protected of living animals. "Marching securely under the guardianship of its thorn-spiked armor, it recks little of any foe save man. . . . The formidable array of bristling spines with which the back is more or less covered offers a

cheval-de-frise of sharp spikes toward any animal that may present itself as an enemy. Another peculiarity is the power possessed by these creatures of rolling themselves into a round ball, by placing the head on the breast, drawing up the legs, and curling the body firmly round the members. By this posture the hedgehogs render themselves invulnerable to almost any animal that may attack them. . . . When in this curious attitude, the hedgehog can not be unrolled by main force, as long as any life remains in the body, for there is an enormously developed muscle, with a very thick margin, which spreads over the back and round the sides, and which, when contracted, holds the creature in so firm an embrace that it will be torn in pieces rather than yield its point."

The spines of this animal are about an inch long, and naturally lie flat on the back, directed toward the tail. But by a peculiar arrangement they are erected when the owner coils himself. In shape the spine "is not unlike a large pin, being sharply pointed at one extremity, and furnished at the other with a round, bead-like head, and rather abruptly bent near the head. If the skin be removed from the hedgehog, the quills are seen to be pinned, as it were, through the skin, being retained by their round heads, which are acted upon by the peculiar muscle which has already been mentioned.

"Protected by this defense, the hedgehog is enabled to throw itself from considerable heights, to curl itself into a ball as it descends, and to reach the ground without suffering any harm from its fall. A hedgehog has been seen repeatedly to throw itself from a wall some twelve or fourteen feet in height, and to fall upon the hard ground without appearing to be even inconvenienced by its tumble. On reaching the ground, it would unroll itself and trot off with perfect unconcern."

The quills upon the "fretful porcupine" are several inches in length. The absurd belief that this animal could throw its quills at an enemy, after the fashion of a lance, arose from the following facts: "Their hold on the skin is very slight, so that, when they have been struck into a foe, they remain fixed in the wound, and, unless immediately removed, work sad woe to the sufferer. For the quill is so constructed that it gradually bores its way into the flesh, burrowing deeper at every movement, and sometimes even causing the death of the wounded creature. In Africa and India leopards and tigers have frequently been killed in whose flesh were pieces of porcupine-quills, that had penetrated deeply into the body, and had even caused suppuration to take place. In one instance a tiger was found to have his paws, ears, and head filled with the spines of a porcupine which he had vainly been endeavoring to kill. . . . If irritated or wounded, the porcupine becomes at once a very unpleasant antagonist, as it spreads out its bristles widely, and rapidly backs upon its opponent."

Many small creatures are undoubtedly protected by *offensive fluids*

or *odors*, which are not a matter of consciousness or will. In illustration of this method of defense, it will be sufficient to quote the following: "In South America there is a family of butterflies termed *Heliconidæ*, which are very conspicuously colored and slow in flight, and yet the individuals abound in prodigious numbers, and take no precautions to conceal themselves, even when at rest during the night. Mr. Bates found that these conspicuous butterflies had a very strong and disagreeable odor; so much so, that any one handling them, and squeezing them as a collector must do, has his fingers stained and so infected by the smell as to require time and much trouble to remove it. It is suggested that this unpleasant quality is the cause of the abundance of the *Heliconidæ;* Mr. Bates and other observers reporting that they have never seen them attacked by the birds, reptiles, or insects, which prey upon other lepidoptera."

Great numbers of animals are permanently colored so as to harmonize with their favorite surroundings. This *obscure coloring* may be either for the purpose of securing prey, or for concealment. The banded colors of the tiger perfectly blend with the lights and shadows in the jungle-grass. Those forest animals which live on the ground, as game-birds, deer, rabbit, or squirrel, are of brown or neutral hues, which assimilate to the color of dead leaves and tree-trunks; and they are quite impossible to discover as long as they remain motionless. Animals of the desert are dull or rust colored, or of some light tint. Insects, frogs, and lizards, which live among the leaves, are green; those on the ground in dry or rocky places are pale accordingly. Grasshoppers generally have the prevailing hue of the fields where they subsist. Indeed, protective coloration is very common, and any person can find examples.

More remarkable, however, is the protection afforded by what is termed *chromatic function.* "It consists in the power possessed by many fishes, crustaceans, amphibia, and reptiles, of adapting their general coloring, often by extremely rapid alteration, to the coloring of the surrounding objects, so that they seem to be helped by it in the pursuit of their prey, or especially protected against the attacks of their enemies."

This is very striking in many fishes. It can be readily observed in the common tree-frogs. The chameleon and the devil-fishes are famous for their power of changing color when irritated. The degree of consciousness involved in this is unknown.

The *resemblance to inanimate objects* of many small animals, especially insects, is one of the most curious things commonly met with. Insects imitate leaves, sticks, dry twigs, stones, lichens, etc., so perfectly as to sometimes deceive the close observer. The most remarkable examples are found in the tropics, where insect-life luxuriates. Wallace thus describes an Indian butterfly (*Kallima*): "The upper surface of these is very striking and showy, as they are of large size,

and are adorned with a broad band of rich orange on a deep-bluish ground. The under side is very variable in color, so that out of fifty specimens no two can be found exactly alike; but every one of them will be some shade of ash, or brown, or ochre, such as are found among dead, dry, or decaying leaves. The apex of the upper wings is produced into an acute point, a very common form in the leaves of tropical shrubs and trees, and the lower wings are also produced into a

FIG. 5.—LEAF-BUTTERFLY *Kallima paralekta*.

short, narrow tail. Between these two points runs a dark curved line exactly representing the midrib of a leaf, and from this radiate on each side a few oblique lines, which serve to indicate the lateral veins of a leaf. . . . But this resemblance, close as it is, would be of little use if the habits of the insect did not accord with it. If the butterfly sat upon leaves or upon flowers, or opened its wings so as to expose the upper surface, or exposed and moved its head and antennæ as many butterflies do, its disguise would be of little avail. We might be sure,

however, from the analogy of many other cases, that the habits of the insect are such as still further to aid its deceptive garb; but we are not obliged to make any such supposition, since I myself had the good fortune to observe scores of *Kallima paralekta*, in Sumatra, and to capture many of them, and can vouch for the accuracy of the following details: These butterflies frequent dry forests and fly very swiftly. They were never seen to settle on a flower or a green leaf, but were many times lost sight of in a bush or tree of dead leaves. On such occasions they were generally searched for in vain, for, while gazing intently at the very spot where one had disappeared, it would suddenly dart out, and again vanish twenty or fifty yards farther on; on one or two occasions the insect was detected reposing, and it could then be seen how completely it assimilates itself to the surrounding leaves. It sits on a nearly upright twig, the wings fitting closely back to back, concealing the antennæ and head, which are drawn up between their bases. The little tails of the hind wing touch the branch, and form a perfect stalk to the leaf, which is supported in its place by the claws of the middle pair of feet, which are slender and inconspicuous. The irregular outline of the wings gives exactly the perspective effect of a shriveled leaf. We have thus size, color, form, markings, and habits, all combining together to produce a disguise which may be said to be absolutely perfect; and the protection which it affords is sufficiently indicated by the abundance of the individuals which possess it."

Of the walking-stick insects Wallace says: "Some of these are a foot long and as thick as one's finger, and their whole coloring, form, rugosity, and the arrangement of the head, legs, and antennæ, are such as to render them absolutely identical in appearance with dry sticks. They hang loosely about shrubs in the forest, and have the extraordinary habit of stretching out their legs unsymmetrically, so as to render the deception more complete." The counterfeiting is carried even to the imperfections and injuries of the objects copied. Still speaking of the walking-stick insects, Wallace says: "One of these creatures, obtained by myself in Borneo, was covered over with foliaceous excrescences of a clear olive-green color, so as exactly to resemble a stick grown over by a creeping moss or jungermannia. The Dyak who brought it assured me it was grown over with moss, although alive; and it was only after a

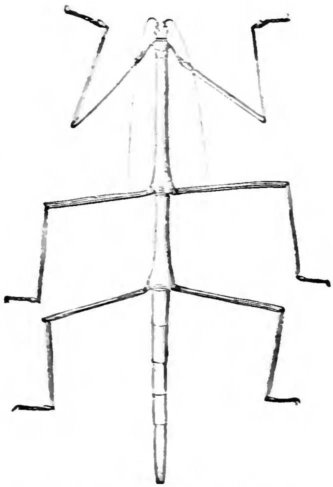

FIG. 6.—*Phasma* sp., a wingless orthopterous insect.

most minute examination that I could convince myself it was not so." And of a leaf-butterfly he says: "We find representations of leaves in every stage of decay, variously blotched and mildewed, and pierced with holes, and in many cases irregularly covered with powdery black dots, gathered into patches and spots, so closely resembling the various kinds of minute fungi that grow on dead leaves that it is impossible to avoid thinking at first sight that the butterflies themselves have been attacked by real fungi."

Mimicry is the resemblance which poorly protected animals bear to others well protected. Several species of edible butterflies imitate the *Heliconidæ* and others, which are protected by fetid odors; other

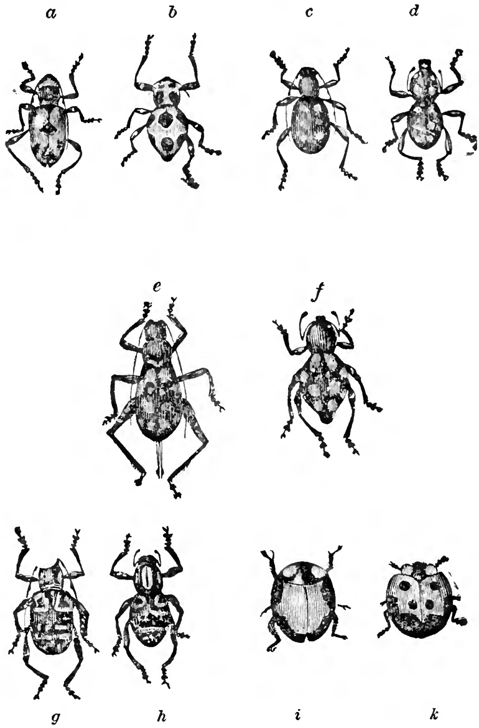

FIG. 7.—*a*, *Doliops* sp., mimics *b*, *Pachyrhynchus orbifer*; *c*, *Doliops curculionoides*, mimics *d*, *Pachyrhynchus* sp.; *e*, *Scepastus pachyrhynchoides* (a grasshopper), mimics *f*, *Apocyrtus*; *g*, *Doliops* sp., mimics *h*, *Pachyrhynchus* sp.; *i*, *Phoraspis* sp. (a grasshopper), mimics *k*, a *Coccinella*. All from the Philippines, of natural size. It is evident that the great similarity of the creatures to those they mimic is less conspicuous in the engraving than in real life, since the exact correspondence in the coloring can not be given here.

butterflies mimic wasps so closely that persons fear to handle them, although the imitation does not extend to the sting. Innocent beetles imitate other beetles which have hard shells or fetid glands. They also mimic bees and wasps. Flies also mimic wasps, and grasshoppers mimic beetles. Some moths almost exactly imitate the form and color of humming-birds. Wallace states that some harmless snakes

mimic poisonous species. And this mimicry is found even among birds.

Active defense implies such organs and methods of defense as are under control of the animal's will, or matters of conscious action. We shall here find much greater variety.

The homes of animals—nests, houses, burrows, etc.—are protection from the storm and for the young as well as from foes. This is a most interesting and extended field, and requires separate treatment.

But many small creatures build individual *shells* or *cases* wholly for defense against enemies. These are frequently carried about with the creature, as armor, wherever it goes. A familiar example, found in any brooklet, is seen in the case of the young caddis-fly. To hide and protect itself from the ever-hungry fishes, the larva of this insect incloses its body in a tube formed by gluing together bits of wood, shells, sand, and all sorts of matter that may be found at the bottom of a stream. This case has a silken lining, and out of the end the larva protrudes its head and legs for locomotion, or wholly withdraws out of sight and danger. Other water larvæ reside within a bit of hollow straw or plant-stem. A similar habit characterizes a group of sea-worms, to which belongs the *Serpula*. Thin tubes may be formed of a limy secretion, or built by cementing sand, shells, etc. One of the tentacles of the *Serpula* is terminated by an expansion which, when the worm withdraws into its case, serves as a stopper (operculum) to securely close the opening (see Monthly, February, 1882, page 452, Fig. 4). The silk *pupa-cases* of the moths are very wonderful, even if very common, examples of artificial covering.

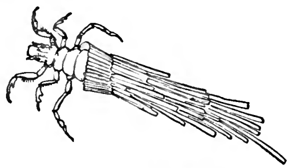

Fig. 8.—Caddis-Worm, with its Case.

The singular hermit-crabs are obliged, on account of their lack of a hard epidermis, to inhabit some empty mollusk-shell. And they are exactly fitted for that sort of life: the tail-fin is changed into hooks for holding the shell; some of the legs are strong levers for dragging its heavy house; and one of its claws is disproportionately large, in order to close the opening of the shell.

Keen senses combined with *swiftness of locomotion* are the chief reliance of birds and mammals. The rabbit is a fair example. Innocent and timid, entirely without weapons, it is always on the alert. With its large eyes, ears sensitive to the slightest sound, and a delicate sense of smell, it is as difficult to surprise as it is to "catch a weasel asleep." Every deer-stalker knows he must approach his game on the side opposite the wind. Most mammals, especially the herbivorous, scent danger, and flee away. Many of them use their natural weapons only when brought to bay, and in despair. This is true, indeed, of many carnivorous beasts when they are not bold with hunger. Birds rely, for warning of foes, more exclusively upon their eyes.

Excepting from man, the birds and beasts of prey have little to fear. Their offensive weapons are terribly effective. And, besides *teeth* and *claws*, the lion and tiger can strike such *blows* with their paws as will kill a buffalo at a stroke. The cud-chewing mammals have *horns* which may, with even the most timid, be efficient as a desperate resort. These are of various kinds as regards form, structure, growth, and duration. The principal kinds are represented by those of the deer, giraffe, antelope, and ox. The efficiency of these natural weapons is greater than would be imagined from a knowledge simply of our domestic animals. The water-buffalo of India (to quote from Wood) "is a most fierce and dangerous animal, savage to a marvelous degree, and not hesitating to charge any animal that may arouse its ready ire. An angry buffalo has been known to attack a tolerably sized elephant, and, by a vigorous charge in the ribs, to prostrate its huge foe. Even the tiger is found to quail before the buffalo, and displays the greatest uneasiness in its presence." Of the *gaur*, Wood says, "These herds . . . in their own domains bear supreme rule, neither tiger, rhinoceros, nor elephant daring to attack them." Some antelopes are on occasion quite a match for the lion.

The horn of the rhinoceros is very different from those of the ruminants. Its peculiar situation on the nose makes it a very ugly and efficient weapon. It is placed on the middle of an arch of bone, the latter being free at one end so as to give elasticity. Many animals, particularly the horse tribe, make excellent use of the *feet*. Of the use of the hind-feet, the mule is a striking but somewhat threadbare illustration. The elk and related animals strike with the fore-feet, and are able to cope with a dog or wolf.

The ostrich and the secretary-bird also *kick;* and the latter, as is also true of many birds, gives heavy blows with its wing.

The kangaroo uses his hind-feet less to kick than to *cut* and *disembowel* his antagonist. The bear employs much the same tactics. He *hugs* and crushes his antagonist with his fore-legs, and strikes and tears with either foot.

The elephant uses his great weight to literally crush his foe. But his weapon is his elongated *nose*.

Another example of the nose used as a weapon is found in the sword-fish. Here the bones of the skull are produced to form a thick beak, or *sword*, which points forward directly in a line with the body. With this lance, five or six feet long, the fish is able to pierce even through a ship's bottom. The British Museum is said to contain a sword imbedded in the planking of a ship. Accounts have been given of the sword-fish attacking and even killing the whale.

The saw-fish, a sort of shark, has a similar beak, not sharp pointed, however, but blunt and armed with teeth on either edge. It can be used as a lance, and has been deeply driven into a ship's timbers. It is used mainly for striking, and, if the animal attacked is moving, the

effect is a saw-cut. It then acts as a veritable *saw*. But it seems absurd for an animal to carry teeth on the outside of his nose.

With another shark the *tail* is a weapon, as it is with the whale also. The tail of the thrasher is extremely large, and can deal severe blows. The thrashers have been known to attack the whale when the latter is at the surface. It is conjectured that the thrashers and the sword-fish form a conspiracy against the whale, and, while the latter prevent the whale from diving, the former leap out of the water and bring their huge tails down on the naked back of the whale with a tremendous slap that can be heard a long way. Probably the whale is more frightened than hurt.

Some rays or skates have the tail long and whip-like. It is covered with sharp spines, and forms an effective instrument for either striking or grasping. These spines produce severe inflammation, and are greatly dreaded by fishermen. The larger ones are much used by savages for edging weapons. It is supposed that the whip-ray seizes an enemy, or its prey, with its tail, and kills it by the cutting spines on its tail, and by pressing it against the barbed spine situated on its back. These *spines* are commonly used as spear or arrow heads by the savages of the South Sea.

Some small creatures have *forceps* or jaws as weapons. Those of the lobster are modified feet, while those of the beetle are mouth-parts.

The most elaborate organs of defense are found in the lower forms of life. And at near the lowest point in the animal scale we find an apparatus exceedingly complex and efficient. This is the "nettling-threads," "lasso-cells," or *cnidæ*, which give the hydra, jelly-fish, and

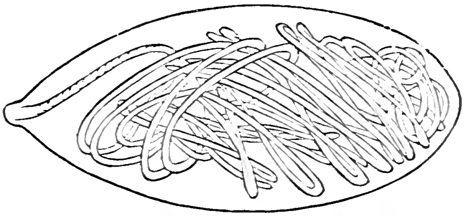

FIG. 9.—LASSO-CELL, CONTAINING BARBED FILAMENT. (After GOSSE.)

polyps their power of stinging. They are also possessed by the crinoids, some naked sea-snails, and some sea-worms. Like many other weapons, they are used to subdue prey as well as to repel enemies. These creatures are soft and delicate, and would seem to be the easiest food for other animals. The *cnidæ* are probably their only defense, but they seem quite sufficient. A chapter would be required to give a full description of these wonderful weapons. The instrument consists of a hollow filament, coiled in a sac, the whole of microscopic size. The sacs are commonly on the surface of the tentacles and other free surfaces of the body. In some species they are collected in thread-

like magazines which are shot out of the body-walls. Upon irritation this hollow thread is thrown out of the sac to a great length, by eversion. It is turned inside out, and then exposes a barbed surface. They penetrate the soft tissues of the animal attacked, and convey a poison fatal to small animals. Any bather who has ever been stung by a jelly-fish can give a satisfactory account of the effect of these weapons. There is no doubt that a man would be completely and quickly paralyzed if entangled, in a nude state, among the tentacles of the larger jelly-fishes.

The *stings* of insects are more familiar, but still very wonderful. In the sting of the honey-bee "we see an apparatus beautifully contrived to enter the flesh of an enemy; two spears finely pointed, sharp-edged, and saw-toothed, adapted for piercing, cutting, and tearing; the reversed direction of the teeth gives the weapon a hold on the flesh, and prevents it from being readily drawn out. Here is an elaborate store of power for the jactation of the javelins, in the numerous

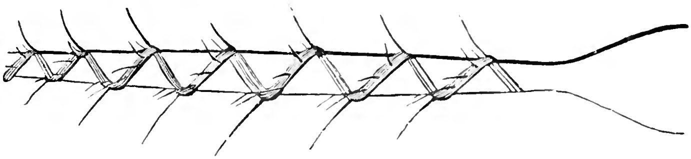

Fig. 10.—Barbed Case of Everted Nettling-Thread. (After Gosse.)

muscular bands; here is a provision made for the precision of the impulse; and, finally, here is a polished sheath for the reception of the weapons and their preservation when not in actual use. All this is perfect; but something still was wanting to render the weapons effective, and that something your experience has proved to be supplied." This is the poison, which has also a complex apparatus for its secretion and ejection. This sting is a modified ovipositor, and possessed only by the females, or neuters, which are undeveloped females. The male insect is always a mild and inoffensive creature.

Scorpion-stings are similar to those of insects in position and use, but are unlike in origin and development.

The *poison-fangs* of venomous snakes are modified teeth. They are so attached that when not in use they lie in a fold in the upper jaw. The poisonous snakes have broad heads, on account of the muscles which control the fangs and the large glands which secrete the venom. The latter is a sort of saliva, probably charged with fermenting organisms, which are harmless in the food-canal, but which in the blood multiply with amazing rapidity. The poison is conveyed to the wound by a groove in the side of the fang.

The fangs of spiders represent the antennæ of insects. They are tubular, for conveying venom, and jointed. The point or terminal joint when not in use shuts into the basal joint, like the blade of a

pocket-knife into its handle. The fangs of the scorpion are modified feet.

Certain fishes have the power of storing a large quantity of *electricity*, which is used at will to paralyze and kill prey or enemies. The electric eel can kill small fishes at a distance, it is said, of fifteen feet; and they sometimes kill the horses which are driven into the pools for the purpose of exhausting and capturing the eels. The electricity is stored in a peculiar tissue of large cells or tubes which act like a battery of so many Leyden-jars. Apparently nervous force is here converted into electricity. After giving several shocks, the creature is exhausted for a time.

Besides those creatures which are passively offensive by their odors, there are others which can at will *expel fluids* to offend and deter enemies. The skunk need only be named, and the point will be fairly grasped by the reader. Some reptiles have the power to expel an offensive fluid from glands in the skin. The toad and salamander are examples. This fluid is acrid and biting, and intensely irritating to delicate skin, as the mucous membrane of the mouth or eye. The abundance of this viscid yellow fluid in the salamander probably led to the ancient notion that this little amphibian could withstand and extinguish fire. The water-beetle (*Dytiscus*) also expels a nauseating fluid.

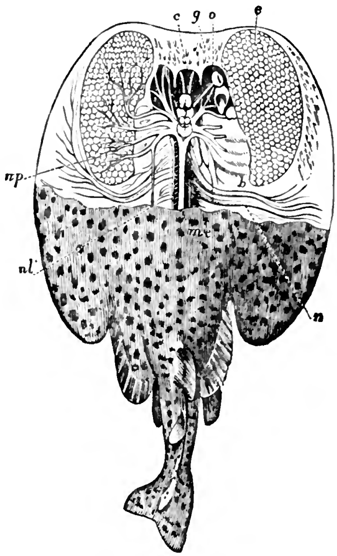

Fig. 11.—The Torpedo, with its Electrical Apparatus displayed. *b*, branchiæ; *c*, brain; *e*, electric organ; *g*, cranium; *me*, spinal cord; *n*, nerves to the pectoral fins; *nl*, *nervi laterales*; *np*, branches of the pneumogastric nerves going to the electric organ; *o*, eye.

It is very curious to find how some weak and lowly creatures succeed in frightening away their powerful foes. They assume a virtue which they do not possess. "The *attitudes* of some insects may also protect them, as the habit of turning up the tail, by the harmless rove-beetles, no doubt leads other animals, besides children, to the belief that they can sting. The curious attitude assumed by sphinx caterpillars is probably a safeguard, as well as the blood-red tentacles which can suddenly be thrown out from the neck by the caterpillars of all the true swallow-tailed butterflies."

Many creatures produce *sounds* for the same purpose. The cat spits. Snakes hiss. The porcupine rattles his quills. "Even the preliminary rustle of the quills with which a porcupine generally prepares every attack is sufficient to make an ordinary horse flee in terror." Perhaps the sounds produced by certain naked sea-snails are in some degree for defense.

Various lizards abash their enemies by expansion, protrusion, or erection of *appendages*. The iguana has a bag beneath the neck which it puffs up. The frilled lizard of Australia has a sort of Elizabethan collar about its neck which it can suddenly expand, to astonish and put to flight the approaching enemy. And the basilisk of South America has fin-like appendages upon its back and tail which it can erect if annoyed. The chameleon inflates his body with air, that he may appear to be a much bigger creature than he really is. From this sprang the belief that the chameleon lived on air.

The *phosphorescence* of animals is a subject not yet fully explained. But without doubt it is partly defensive.

One of the most queer and ludicrous methods of protection is seen in the bombardier beetles. In description of this, listen to Pouchet: "They alarm their enemies by means of real *artillery*. These coleoptera when threatened suddenly expel from their intestines a whitish acid vapor, the explosion of which as it issues produces a certain sound, a slight detonation, which carries disorder among the aggressors. This explosion may even be repeated a certain number of times. Hence, when one of these insects is pursued by an enemy, it fires off its artillery anew. The instinct of defense is so inherent in the tribe of bombardiers that, at the sound of a cannon-shot from one of them, all the others fire at the same time; there is a running fire along the whole line. The sound produced by these coleoptera is intense enough to startle those who do not know the *ruse*."

Truthfulness is not an inherent virtue of animal character. Many are the tricks, deceits, and devices by which they selfishly seek advantage. A common artifice is that of *feigning death* in order to escape the reality. "Playing 'possum" is a dodge not confined to those higher animals to which we in our condescension grant the possession of a degree of intelligence. The larva of the dytiscus, knowing the preference of fishes for living active prey, when seized immediately becomes flaccid and limp. The fish, supposing he has seized only a carcass, drops it in disgust, and the dytiscus makes the most of his opportunity. When the insect becomes a hard-skinned beetle, it, of course, loses this power, and then employs a disgusting fluid, as before mentioned.

Every collector of insects becomes familiar with species which have the habit of *quietly dropping* from the plants on which they feed to the ground, upon the least alarm.

Hunters are familiar with many wiles by which pursued animals endeavor to elude their pursuers and *throw them off the scent*. The fox has the habit of doubling on his track, of walking fences, and going into water. Wood thus describes the habit of a South African antelope, the duyker-bok: "If the sportsman should happen to overtake this buck, it will lie still, watching him attentively, and will not move until it is aware that it is observed. It will then jump up and

start off, making a series of sharp turns and dives, sometimes over bushes and at others through them. When it conceives that it is observed, it will crouch in the long grass or behind a bush, as though it were going to lie down. This conduct is, however, nothing but a *ruse* for the purpose of concealing its retreat, as it will then crawl along under the foliage for several yards, and, when it has gone to some distance in this sly manner, it will again bound away."

When a slug or naked snail enters a bee-hive, the bees fall upon him and sting him to death, as a matter of course. But what to do with the carcass then becomes a vital question. And now is exhibited the wonderful intelligence of the social insects. The body is too large for the bees to move; but if left it will breed pestilence. They cover it with wax; they embalm it, as did nations of old their dead. But a shelled snail entering the hive is invulnerable to their weapons, so they cement his shell to the bottom of the hive. It is a sentence of imprisonment for life, with no hope of pardon. Yet such manifestations of thought we call "instinct," because we wish to monopolize "intelligence."

Oddest of all defensive methods is that of *snapping off the tail.* The blind-worm, or slow-worm, is a little snake-like lizard common in

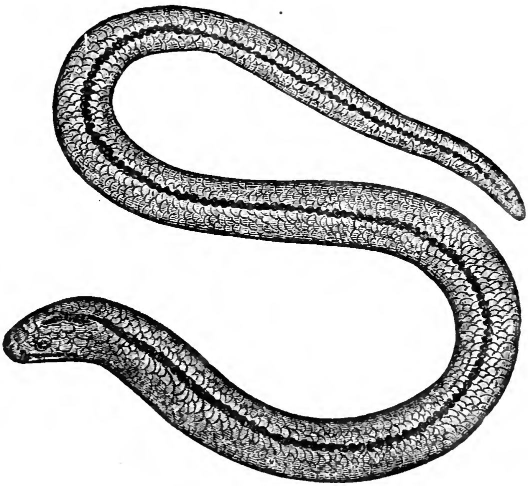

Fig. 12.—Blind-Worm (*Anguis fragilis*).

the Old World. When alarmed it contracts its muscles in such manner and degree as to break its tail off at a considerable distance from the end. But how can this aid it? The detached tail then dances about very lively, holding the attention of the offender, while the lizard himself slinks away. And for a considerable time the tail retains its capability of twisting and jumping every time it is struck. The lizard will then grow another tail, so as to be prepared for another

adventure. There are other lizards which have a similar power, though in less degree. The American glass-snake, so called, is one.

Semper describes certain snails of the Philippine Islands which do the same thing: "Every species (*Helicarion*) that I personally examined possessed the singular property . . . of shedding their tails when they are seized somewhat roughly, at a little way behind the shell. This they do by whisking the tail up and down with extraordinary rapidity, almost convulsively, till it drops off; if the creature is held by the tail it immediately falls to the ground, where it easily hides among the leaves. . . . These snails at first constantly escaped me and my collectors in this way, and not unfrequently we had nothing but the tail left in our hand."

BRAZILIAN DIAMONDS AND THEIR ORIGIN.

By M. H. GORCEIX.

THE discovery of the diamond-beds of the Cape of Good Hope, with the extraordinary abundance of their yield, seems to have caused it to be forgotten that the empire of Brazil only a few years ago had the monopoly of that precious stone, as it still has of the finest crystals. Hopes have been entertained that the examination of the green serpentine, in which the Cape diamonds are scattered, would permit a determination of its origin and its primitive bed. No doubt, however, now exists that the magnificent crystals incased in that rock were already in existence when in its upward course from the depths of the earth it brought them along with it and left them where they are now found. Unless, then, new discoveries are made at the Cape, of beds of a different nature, it will be necessary to look to Brazil for the solution of the question of the primitive bed, the origin and the mode of formation of the diamond—a triple problem which appears, down to the present time, to exist as a challenge to all who are occupied with geology and mineralogy.

The diamond has been and still is mined at numerous points in Brazil, which are situated chiefly in the provinces of Bahia, Goyaz, Matto Grosso, Parana, and Minas Geraes. Except in the last province and in that of Bahia, they give occasion only to the labors of isolated diamond-workers, the *garimperos* of Brazil, who wash the sands of the streams in large wooden bowls. The principal diggings in Minas Geraes are grouped around the city of Diamantina, which is situated almost on the meridian of Rio Janeiro, about five hundred miles from the coast. A few other districts also furnish small quantities of diamonds. We shall consider especially the diamond-beds of Diamantina; and we need not then speak of the others, for they are all so

nearly alike that the study of one of them is enough to give an exact idea of the others. The country here is not one that we have to discover, but to make known, and it well repays a better acquaintance. If we go to it we shall run no dangers, we need fear or seek no thrilling adventures; but we may feel as much ease in traveling as we enjoyed a few years ago in going from Florence to Bologna, or on the road to the Apennines. The security is even greater. It is said that in Mexico military convoys have been necessary to guard the trains engaged in the transportation of silver from the interior to the coast, and that even these guards did not protect them. Never has a single soldier or a single agent of the police been employed in such service in Brazil. For nearly two centuries successive caravans and numerous travelers have transported to Rio Janeiro from the most remote points of the interior fortunes in diamonds or in gold, simply packed in wooden boxes; yet we can not cite a theft that has been committed on the roads, now great highways, which were still, hardly fifty years ago, simple bridle-paths traced through virgin forests.

The rocks are at first schistose; then, in the environs of Ouro Preto, the capital of the province, appear quartzose formations, sandstones, and quartzites. These rocks constitute the peak of Itacolumi and the enormous mass of Caraça, the landmarks that guide us. After a while the white or green mica of the quartzites is replaced by spangles of oligist iron, and for several leagues the dust of the road and the pavements of the streets of the towns through which we pass are formed of the most beautiful iron minerals in the world. Quartz, mica, and oligist iron are not generally elements of a very fertile soil, but, under the action of a considerable humidity, these rocks are disintegrated and decomposed. Wherever the hand of man has not carried destruction, there is developed, under the influence of a favorable climate, one of the finest vegetations in the world.

We are now in the land of gold. The road is everywhere marked with the ancient diggings; enormous heaps of gravel on the banks of the streams indicate how considerable have been the excavations of which we see only the persisting marks.

The rocks are always the same: mica-schists, quartzite containing mica or oligist iron, or itabaryte. The aspect of the country does not change: mountains succeed mountains, all of them rounded, gradually sloping on one side, carved into peaks on the other; and, since we follow generally the water-sheds, we have only brooks to cross, the sources of all the rivers that finally form the Rio Doce. But, after having passed the town of Serro and crossed, a few miles north of this, a chain of mountains perpendicular to the grand crest we have been following, the aspect wholly changes. Before us extends a vast plain, on which the eye hardly distinguishes a few undulations rising around the city of Diamantina, the red roofs of which are visible through a bouquet of verdure that forms a green oasis in the midst of the sur-

rounding desert. On the right, toward the east, we may perceive a peak, the summit of which, constantly surrounded with clouds, has never been reached—less on account of its height, which is not much more than six thousand feet, than of the precipices and deep clefts which forbid approaching it. It is the peak of Itaubé. On the left is seen a less elevated mountain, formed of a single block of rounded, rough-grained quartzite, which has been given the name of *Pedra Redonda*. From around these two peaks rise the principal brooks that, united, form the Jequitinhonha, a stream the sands of which yield diamonds to a considerable distance below Diamantina.

The quartzose rocks predominate everywhere; the schists are seen only at rare intervals, and in their beds. But those rocks, of which quartz in grains forms the principal element, are different from those we have met in the gold-bearing region. They are more granular, only slightly micaceous; they pass into real sandstones; and the beds, generally inclined a few degrees toward the east, are less dislocated, less metamorphic than those of the schists and micaceous quartzites which they cover, and which form an islet on which is situated the city of Diamantina.

To these quartzites and sandstones are added, on the banks of the Jequitinhonha and some of its affluents, conglomerates of rounded pebbles, the horizontal beds of which occur in the same region on the banks of the Paruna, a stream emptying into the Rio das Velhas. The schists and the lower quartzites containing green mica appear around Diamantina, and in patches in the bottom of the ravines through which the Jequitinhonha flows. Quartzites, sandstones superior to the preceding, and conglomerates crowning the whole series, such are the formations, to which heaps and dikes of diorite should be added, which form the soil of this diamond-bearing basin.

The surface, in consequence of the nature of the dominant rock, is covered with a bed of white sand marked by brilliant crystals of quartz derived from the numerous veins of that substance which penetrate all the strata. Of vegetable mold there is not a trace, except in the bottoms of the ravines. In the dry season, a few *kylmerias*, with knotty trunks and a thick rough bark like that of the cork-oak, humble *melastomas* with yellow and red petals, and the *opuntias*, with their straight stems covered with a spiny down, are not sufficient to hide the aridity of the soil. No cultivated fields, but widely scattered houses. Everywhere, however, the ground is dug deeply, and turned over, more by the hand of man than by the action of the elements; but the only product demanded of the earth is the diamond.

The region forms a vast ellipse, the major axis of which, running from north to south, extends about fifty miles from the city of Serro to the little river Caethe Mirim, and the other axis more than twenty-five miles from the Jequitinhonha to a line parallel with the Rio das Velhas. It is, in effect, situated in the valleys of both these rivers,

while a strip of it in the south, near the city of Serro, belongs to the basin of the Rio Doce. Capital differences are marked in the distribution of the diamond-bearing beds of these valleys.

In the basin of the Jequitinhonha, nearly all the water-courses, however insignificant, are or have been diamond-bearing from their sources to their mouths at that river. In the basins of the Rio das Velhas and of the Rio Doce, the streams cease to yield diamonds at a short distance from their source.

In these streams, the diamond is always accompanied by gold in flakes or in little nuggets; but while the diamond prevails in the center of the diamond-yielding region, as we move toward the east, the proportions are reversed: gold becomes more abundant; and finally, after having passed the city of Serro, it is the only precious substance contained in the sands. To this point penetrated, at the beginning of the eighteenth century, those bold adventurers, bands of whom, seeking gold for nearly a half-century previously, had crossed the mountains and reached the middle of the forest of the Sierra d'Espinhaço, dispossessing the tribes of savages whose last representatives still live miserably on the banks of the Rio Doce.

Often, down to 1729, the gold-hunters had noticed, in the bottoms of the bowls in which they washed the river-sands, little bright crystals, to which they attached no value. The brilliancy of these crystals, their hardness, and their regular form, as if shaped by the hand, had indeed attracted the attention of the miners, and many had saved them to use as counters in play; but gold alone had any value in the eyes of these adventurers. At this epoch, according to the least uncertain tradition, a monk, who had taken part in the search for diamonds in India, recognized the nature of these counters. He told his discovery to a certain Bernardo da Fonseca Lobo, who made it known in his name to the Portuguese Government. The king immediately took possession of all the lands where the presence of diamonds had been recognized, and where it could be suspected.

Bernardo received as his reward the title of royal notary, and the command of the militia of the most important city of the region. The name of the monk was forgotten. I do not believe that the name of either could have been popular at Minas, for their discovery, which threw hundreds of millions into the treasury of the kings of Portugal, was the origin of one of the most despotic rules that any country ever had to endure.

The first diamonds were found in the sands of the brooks: and these sands, or, to use the Portuguese expression which has passed into nearly all languages, *cascalhos*, still constitute the beds that are principally worked. But beds of an entirely different nature, situated, like mines of metals, in the midst of the strata, and of corresponding depth, have been brought to notice in later years.

The diamond-bearing cascalhos not only occupy, or rather did oc-

cupy—for most of them have been worked—the beds of all the water-courses, but they were also placed in beds on the table-lands and in the gorges of the mountains, at levels which the waters never reach in our day, even in times of freshet. They have a peculiar appearance, that never deceives the eye of the experienced miner. At first sight, they resemble the gravels of our rivers. They are formed of rounded pebbles of various colors, and are composed of numerous species of minerals, of which I, still only at the beginning of my studies of the subject, have already recognized more than thirty. Of these, quartz, the oxides of titanium, titanic iron, tourmalines, phosphates, fibrolite, octahedric oligist iron, and magnetite, which are well known to the miners and distinguished by them under various fanciful names, are the true satellites of the diamond, its veritable train, and are with rare exceptions sure to be found with it at Diamantina. They have so intimate a connection with it, in fact, that we are justified in believing that the same formations include the primitive beds both of these minerals and of the diamond. The form of the specimens leaves no doubt as to the causes to which they owe it. They have been brought down by the waters and worn round by friction. They can not, however, have been turned into spherical balls by a simple transport of a few hundred yards. The diamond itself, the hardest of all bodies, has not escaped this action; and fragments of it are found from which every trace of crystallization has disappeared, and which are as round as marbles. Not the sands of the large streams alone, but also those of the smallest brooks, even those near their sources, present the same characteristics. The stones must, then, owe their shapes to the polishings which they have suffered by being held in the windings of the rocks and rolled around them by the eddies of the waters. While they have been thus polished off, they have produced an analogous phenomenon on the bottoms of the rivers, where they have caused the wearing out of those circular holes—the "giants' pots," the *caldeiroes* of the diamond-hunters, with which the beds of the streams of Diamantina are pock-marked. The sands in these holes are naturally richer than the other sands; for the lighter elements are carried away by the water, and more fragile substances than the diamond are ground to powder in them. For a hundred and fifty years the miners have considered it a piece of great good fortune to discover one of these caldeiroes; but new ones are now very seldom found. A few hundred yards above the bridge of the Diamantina road over the Jequitinhonha, the course of the water is barred by enormous blocks of diorite, between which the current has excavated subterranean passages. The river having been partly turned from its course, one may now go into one of these grottoes, which is occupied by a cascalho of extraordinary richness. The sides of the rock are as polished as the best-worked marble; the light of the torches is reflected as from a glass; and the visitor perceives at every instant cylindrical holes as regularly formed as if some skillful potter had shaped

them on his wheel. The discovery of some of these caldeiroes after expensive labors, some thirty years ago, afforded sufficient return to enrich the families of the two partners who worked them. An eye-witness to the fact relates that in one of the holes under the diorite arch, when the superficial layer of sterile sand was removed, a clear mass of the precious stones was revealed, and the discoverers were able on the spot to fill their pockets with diamonds. In the Ribeirão do Inferno, a single caldeiroe of a few cubic metres' capacity furnished nearly 8,000 carats of diamonds. Such fortunes, however, are extremely rare, and can not be counted on in the regular mining.

It is easy to comprehend how powerful must have been the action of the erosion above described, the duration of which is measured by many millions of years, but is quite outside of our chronology. The greater part of the ravine through which the Jequitinhonha flows, as well as the whole groundwork of the hydrographic system of the region, is doubtless due to phenomena of upheaval, the directions of which oscillate around a north-and-south axis. The tributaries of that river have cut out channels for themselves which are now deep, close cañons, with sharply cut, precipitous walls.

The almost horizontal disposition of the sandstone strata, and of the conglomerates, which form the banks of the rivers, and the terraces which indicate the successive levels occupied by the river-bottoms, leave no doubt of the correctness of this assertion. At first, consequently, the bottoms of the streams were almost at the level of the surface; the rivers overflowed their banks after light rains, and their diamond-bearing sands were spread over the table-lands and in the mountain-gorges. As the beds of the rivers were worn down deeper in the rock, overflows became more rare, and the sands were carried to only small distances from the banks. Finally, after a certain period, inundations became impossible, and the sand was deposited in the caldeiroes, the caves, and subterranean channels which the river wore out in the rocks over which it flowed. This epoch may be referred to the period which preceded our own, and which is characterized in Europe by the stone implements of human origin and use, specimens of which have been found in the diamond-bearing land.

Then, either by a rising of the coast, or, as is less probable, by a subsidence of the central plateau of Minas Geraes, the fall of the streams diminished, and, instead of continuing to excavate their beds, they began to fill them with the diamondless, shifting deposits, the formation of which is continued into our day. The sands of the table-lands and the banks of the rivers are much less rich than those of the streams; and in any case the diamonds have to be separated, by methodical washings, from the foreign substances with which they are mixed. Very rarely a simple sifting with the fingers suffices to extract the jewel. In 1824 a region was discovered in the lower part of the table-land of Diamantina where the diamonds were scattered

through the soil, accompanied only by a few bits of quartz. According to the popular expression, the crystals of the precious stone could be picked out of the roots of the grass when it was pulled up. A diamond of twenty-eight carats was found on the surface of the ground. At some distance from this spot, I have myself seen, on the summit of the ridge between the valleys of the Jequitinhonha and the Rio das Velhas, diamonds in ground-cracks some inches deep, with no other companions than enormous crystals of quartz. Cavities in the rock a few metres away did not contain a trace of diamonds, although they bore identical crystals of quartz. The old miners ascribed the disposition of the minerals they sought in regular veins to the intervention of good genii. It seems as if, at Diamantina, a wicked fairy must have sown the diamonds on the ground according to its caprices; and never were caprices more whimsical and varied. The diamond there forms only an insignificant part of the gravels, and is in most uncertain proportions.

The work of washing the diamonds is done wholly by hand. In the first operation, the sands are placed, in portions of two hundred to two hundred and fifty pounds, in a kind of hod or rectangular trough, only three sides of which are inclosed. The hods are arranged by twos, fours, or sixes, by the side of a trough of water about a foot and a half deep, so that their bottoms shall be slightly inclined toward it. A workman, standing in the trough before each hod, dashes water upon the sand in it. The clay and the very fine sands are carried away, and the first separation is made. The larger pieces remaining in the top of the sand are picked away; the diamond is to be found in the two upper thirds of the mass that is left, the lower part being nearly sterile. The washing is afterward finished in bowls a little deeper and a little more conical than those used by the gold-washers. The washer puts the sand in the bowl and fills it with water; then by whirling the bowl and shaking it up and down while the sand is floating around in it, and being careful to stir it from time to time with his hand, he determines a classification in the order of density. This work is easy if he is washing gold; for that metal is heavier than the substances with which it occurs, and always goes to the bottom.

The diamond, however, having a density about three and a half times greater than that of water, and more considerable than that of quartz and tourmaline, but less than that of the oxides of iron and titanium, its constant companions, settles in the middle layers. The washer, after several rinsings, removes the upper particles, hardly looking at them, and, when he has reached a certain level, which his skill recognizes at once, tips his bowl slightly, so as to let the water run off in a thin film, and, perceiving the glittering crystals of the diamond, picks them out with his fingers. The vigilance of the overseers must be redoubled at this stage, particularly when slaves are employed; for I know of nothing equal to the skill of the slaves in find-

ing diamonds, except that with which they make them disappear if the vigilance of the superintendent is relaxed for an instant. I can not describe all the artifices employed, but I should remark that, since the works have become free, fraud has greatly diminished. Under the old rule it overtook half the diamonds in the gravels.

Difficulties of another kind are presented when the precious gravels are situated in the beds of the rivers. Since the channels have been deeply cut in the rock, and are bordered by steep cliffs, it is impossible to construct lateral sluices for turning the water away from them, except at an expense which even the magnificent return that is anticipated will not justify. A quicker and more simple process has been devised. The river is dammed, and a flume is made of planks to carry the water from the dam to some three or four hundred yards below. The intervening space between the dam and the end of the flume, in which the precious gravels of the caldeiroes are supposed to be situated, is thus left free from running water, while the water which stands upon it and that which reaches it by infiltration are removed by pumps worked by water-wheels. The work must be done quickly when this system is employed, for there is no time to lose. The river is generally docile enough during the dry season, from May to October; but, if only a slight storm comes on, it is transformed at once into a torrent that nothing can resist, and which carries off dams, wheels, and viaduct. This is what happens, as a rule, fifty times out of a hundred. I know of diamond-seekers who have recommenced for three or four years in succession the same works, to have them every time destroyed under their eyes by sudden freshets. Then a fortunate season has amply recompensed them for all that they had lost. Others have just had time to work for a few days in the rich beds, a few cubic yards of which have yielded them hundreds of carats of diamonds; but how many have exhausted all their resources without reaching this promised land! Nevertheless, no machines, or barrows, or inclined planes are employed, notwithstanding the enormous force furnished by the fall of water in the race is at the disposal of the operator; only picks, shovels, levers to raise the rocks, and, for means of transportation, laborers, who carry on their heads large wooden troughs, which others fill with sand and stones. Nothing can be more picturesque than these great trenches, where crowds of negroes are moving about like ants in an ant-hill, running in gangs to receive their loads, and carrying them away in groups, while they intone songs, which are almost always in the language of the African coast. The excavation becomes deeper and more sinuous; groups of men, like clusters of bees, hang, by the aid of the most primitive of ladders, to the rock-walls, and the work goes on with a feverish ardor. From time to time, the overseers probe the sand with long iron rods. Great is the rejoicing when the existence of the diamond-bearing cascalho beneath the sterile sands is revealed by a peculiar sound which all the miners know.

As great, also, is the disappointment when, as often happens, the probe strikes the rock without meeting the diamonds—they having been already taken away by the miners of the previous century, all traces of whose former presence have been destroyed by the river. This is another risk that the diamond-seekers have to run.

These gravel-beds are not the only treasure-bearers in the diamond-yielding region. The mineral elements of which they are composed have been washed by the waters from more ancient rocks. Now, what are these rocks? Do they still exist, or have they been wholly destroyed? To answer these questions, I have carefully endeavored to determine the group of minerals which I have called the satellites of the diamond, persuaded that, wherever their primitive bed should be found, there would also be met that of the diamond. Now, all around the city of Diamantina, and for more than twenty miles west of it, the dominant rocks are quartzites with green mica, and beds of schists of the same nature and the same age as those of the auriferous formations. They are traversed by numerous veins of quartz containing oxides of iron, titanium, and tourmalines, the satellites of the diamond in the river-gravels. The origin of the latter is evidently due to the destruction of these rocks by the action of the waters; and we may, therefore, conclude that they ought to contain the primitive bed of the diamond.

The study of the geographical distribution of the diamond-bearing streams leads us to the same conclusion. All the streams, the sands of which have been found to be richest in diamonds, depart from this zone.

These deductions are confirmed also by the two facts of the discovery of the diamond in place in the sandstones with green mica, two hundred miles from Diamantina, and the discovery of clay-beds, formed from the decomposition of the schists intercalated in the quartzites, twenty miles west of the same city, where rise two rivers, the Rio Pardo and the Caethe Mirim, celebrated in the annals of the miners for their richness. The idea that the Brazilian diamonds were found only in alluvial deposits was so firmly rooted that at first no one attached importance to these discoveries. I was myself incredulous respecting them till I was able to verify with my own eyes the existence of the diamond in the rocks in place. I distinguished three formations: one white, with considerable quantities of crystals of quartz; a second gray, composed almost entirely of oxide of iron; the third, the strongest, of mottled clay, with considerable quantities of the same crystals, of rutile and oligist iron, which I have already pointed out as occurring in the river-gravels. All the formations are strongly inclined toward the east, and are intercalated with micaceous quartzites, the turns of which they follow; and were, therefore, formed at the same time with them in remote geological epochs, which, in consequence of the total absence of fossil remains, can not be precisely

identified. A comparison of them with other strata of the São Francisco Valley, which are characterized by the presence of palæozoic corals, permits me to affirm that they certainly ascend as far back as the Silurian period. Other travelers, previously to myself, have mentioned this formation, and my friend the geologist Dorville-Derby, who supports my view, has carefully described it. The washing of these clays is performed in the same manner as that of the gravels, and I have myself extracted diamonds from them. In the washing, the minerals which we found rolled and rounded in the river-sands, and presenting an entirely different aspect, came out in perfect crystals, without a trace of wearing. They are the same satellites of the diamond, but still in their primitive bed. The diamonds also of São João da Chapada are characteristic: like the crystals of oxide of iron, their angles are whole; their wrinkled faces and their uniform color have suffered no modification by friction. Should not the same conclusion be adopted for the diamond, and may we not assume that it also is here found where it was formed? It is true that I have not found diamonds actually in the little veins of quartz that traverse these beds, nor in the schists, the decomposition of which has produced the diamond-bearing clays with these same crystals of oligist iron and rutile. But hardly one diamond exists to a million crystals of oligist iron; more than thirty thousand pounds of clay have furnished only ten little diamonds weighing about a carat. It would have been a rare chance to perceive, even with a strong glass, one of these stones, no larger than the head of a pin, in the midst of an enormous mass of sterile substances. Objections may indeed be made to the views which I have presented. The formations in which the diamond is found have not always been in the condition in which we now see them. They are not eruptive rocks, that have come already formed from the center of the earth, but have originated from the destruction of more ancient formations, and have undergone metamorphic action under the influence of which new crystalline elements have been formed within them, and they have assumed the aspect they now present. Why, it may be asked, may not the diamond also have been derived from these primitive formations? And then the problem, instead of having been resolved, is only put back another step.

I may reply to this by asking if the processes of trituration effective enough to reduce crystals of feldspar and quartz to mud and sand would not also have modified the diamonds by smoothing their angles and wearing away their surface; especially, since we have seen that much lighter rubbings have been enough to produce such effects in the streams? I could likewise answer other objections that my mind suggests; and I believe I have shown that the diamond of the alluvial formations of Diamantina comes, like the iron and titanic oxides, the tourmalines and the phosphates, its faithful companions, from the destruction of the quartz-veins intercalated into the palæozoic rocks of

the region. The constant association of this precious stone with those minerals causes me to believe that it has been brought, like them, from the depths of the earth in the condition of a volatile compound, and that it owes its crystallization to a dissociation produced under the action of heat and a considerable pressure. Now, what is this volatile compound?

As to the oxides of iron and titanium, together with what takes place in volcanoes, the synthetic experiments of M. Daubrée leave no doubt that they have come up as chlorides and fluorides. May the case not be the same with the diamond? Its presence in the midst of a crystal of anatase lends support to this hypothesis. This is, it is true, only an hypothesis; but it is an hypothesis based on the observation of phenomena in which I have taken analogy for my guide. Far be it from me to assume that I have resolved the problem. I shall be well satisfied if I shall ever be able to raise the corner of a veil which more fortunate and more skilled men than myself will, I am convinced, eventually remove completely.

It is very difficult to estimate the quantity of diamonds furnished by Brazil. Between 1772 and 1793 the royal treasurer received 877,717 carats of diamonds, or about 38,000 carats a year. At least as many more were stolen or smuggled away. This would make the annual production in round numbers about 80,000 carats; if we assume this average for a total period of a hundred and fifty years, we reach the figure of 12,000,000 carats, or nearly 2,400 kilogrammes (6,000 pounds), or a volume of seven or eight hundred quarts. It is impossible to calculate even approximately the total value of these stones. Generally, the diamonds of Brazil are small; stones of fifteen or twenty carats are rare; and the Star of the South, a stone which was found in the western part of the province, at Bagagem, is the only one of them that calls for a special mention. This diamond weighed, in the rough, 254·5 carats, and, after being cut, 125 carats. Finds like this are very rare; and I know of miners who have washed and washed over the cascalhos of Bagagem for twenty years, without having found a second Star of the South, or even a single diamond of value. They are still, however, far from giving up the search. The total production of Brazil in 1880 hardly exceeded sixteen kilogrammes, or forty pounds (about 80,000 carats). In the same time, the mines of the Cape yielded 2,000,000 carats. The Brazilian diamonds, however, have a very marked superiority in luster and beauty, so great that they have often been taken for Indian brilliants.

THE FUNCTIONS OF AN AMERICAN MANUAL TRAINING-SCHOOL.*

By Professor C. M. WOODWARD, Ph. D.,
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WITH his gentle lance Emerson pricked many a bubble, and, though collapse did not always follow immediately, the wound was always fatal. In 1844, in his essay on New England reformers, he charged popular education with a want of truth and nature. He complained that an education to *things* was not given. Said he: "We are students of words; we are shut up in schools and colleges and recitation-rooms for ten or fifteen years, and come out at last with a bag of wind, a memory of words, and do not know a thing. We can not use our hands, or our legs, or our eyes, or our arms." And again, speaking of the exclusive devotion of the schools to Latin, Greek, and mathematics, "which, by a wonderful drowsiness of usage" had been "stereotyped education, as the manner of men is," he says: "In a hundred high-schools and colleges this warfare against common sense still goes on. . . . Is it not absurd that the whole liberal talent of this country should be directed in its best years on studies that lead to nothing?"

This is evidently too severe, but we must admit that Emerson anticipated and greatly aided a reform which has been gathering strength for a whole generation. Hence it is to-day scarcely necessary that I should present arguments in favor of manual education. The great tidal-wave of conviction is sweeping over our whole land, and the attitude and aspect of men are greatly changed from what they were ten years ago. What I said in 1873 in a public address in favor of technical education was held to be rank heresy. I fear it would be regarded as rather commonplace to-day. The progressive spirit of the age has actually penetrated our thick hides, and we are trying to keep step with the universe.

In every community the demands of technical education have been discussed, and, in every instance when the old system has been subjected to the tests which good sense applies to business, it has been found wanting.

Defective Education.—Is, then, I ask—is the education we give as broad and round and full as it ought to be? Is the time of tutelage most wisely spent? Do the results we secure justify the means and methods we use? Is the relation between education and morality as close as it should be? Does our education fill the definition of

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Pestalozzi? I think to these questions we must seriously answer: No! There is a lack of harmony between the school-house and the busy world that surrounds it. Some have even claimed that we are wrong in supposing that education diminishes crime. Let us see if there is any truth in their position.

You know how often a life is a failure from defective education. Too often do we see young people, who might have been educated to eminent usefulness, cast

> ". . . unfinished
> Into this breathing world scarce half made up."

I have seen poor lawyers, who, under a proper system of training, would have made excellent mechanics, and not a few highly educated, able-bodied men actually begging for the price of a day's board. I recall one man in particular who was able to speak several languages, but because no one would employ him as a linguist he must needs beg, for he knew not how to work. Now, when a man's education has been misdirected, and he is thrown upon the world shackled by outgrown theories, bewildered by false lights, and altogether unprepared for the work which perhaps he was born to do, and when in his extremity he resorts to knavery and violence and fraud to secure what he knows not how to get by fair means, those who directed or should have directed his education can not be held blameless.

The moral influence of occupation is very great. A sphere of labor congenial and absorbing, that fully occupies one's thoughts and energies, is a strong safeguard of morality. If you would keep men out of mischief, keep them busy with agreeable work or harmless play. The balance of employments is fixed by our state of society and the grade of our civilization. Now, if indiscriminately we educate all our youth away from certain occupations and into certain others, as is very clearly the case, some employments will be crowded, and consequently degraded; in others, the choicest positions will be filled by foreigners, and the lowest posts, wherein labor is without dignity, must perforce be filled by those who have neither taste nor fitness for their work. The result is broils, plots, and social disorder.

Thirty years ago an eloquent Frenchman (Frédéric Bastiat) charged the one-sided education of his countrymen with being an actual danger to society. He argued that the "stranded graduates," as he called those who, unable to navigate the rough waters of practical life, had been tossed high and dry on the reefs along the shore, "filled with a sense that the country which had encouraged them to devote their best years to classic studies owed them a living, or a means of living, would become the leaders of mobs and officers at the barricades."

More Light.—When the shadow of death was drawn over the great Goethe, he uttered his last wish for "more light." We must echo his cry, if we would prepare our American system of education for a more glorious destiny. We treat our children too much as the

unskilled gardener treats his plants. He puts them by a window, and pours over them a flood of light and life-giving rays. Instinctively they turn out toward the source of their strength. They put forth their leaves and budding promises, and, as we look at them from the outside, we mark their flourishing aspect and rejoice. But, if we look at the other side, we shall find them neglected, deficient, and deformed. What they want is more light—light on the other side. Were the sun always in the east, our trees would all grow like those on the edge of the forest, one-sided.

So in education, we must open new windows, or rather we must level with the ground all artificial barriers and let every luminous characteristic of modern life shine in upon our school-rooms. We must pay less heed to what the world was two or three hundred years ago, and regard with greater respect what the world is to-day.

The Arts of Expression.—Dr. Youmans recently said ("Popular Science Monthly," May, 1882): "The human mind is no longer to be cultivated merely by the forms or arts of expression. The husks and shells of expression have had sufficient attention; we have now to deal with the living kernel of truth. . . . Under the old ideal of culture, a man may still be grossly ignorant of the things most interesting and now most important to know. . . . Modern knowledge is the highest and most perfected form of knowledge, and it is no longer possible to maintain that it is not also the best knowledge for that cultivation of mind and character which is the proper (i. e., the highest) object of education."

I desire, for a moment, to direct your attention to the arts of expression. Next in rank to the ability to think deeply and clearly is the power of giving clear and full expression to our thoughts. This last can be done in various ways. As this brings me squarely upon a subject I wish to impress strongly upon you, I will illustrate it by a somewhat elaborate example:

A gentleman recently called upon me for my opinion concerning a certain automatic brake for freight-cars. The device was new to me, but it lay pretty clearly defined in the mind of my visitor. It was not original with him, but for the purposes of my illustration it might have been. Before I could pass judgment, the device must lie as clearly in my mind as, perhaps more clearly than, it did in his; so he set out to express his thought. He was what we call well educated, being a graduate of the oldest university in the land, and was well versed in the conventionalities of spoken and written languages. Accordingly, he proceeded to utter a succession of sounds. His lips opened and shut with great rapidity, and without intermission a series of sounds fell upon my ears. The sounds I heard were quite familiar to me, as I had been listening to them in one order and another for over forty years, and, as they had always been associated in my mind with certain concrete things and the relations of such things to each

other, certain thoughts about those things began to take shape in my mind.

Of course, the sounds I heard had not the smallest likeness to the things called up by them in my mind. To an Italian peasant, or to Archimedes of Syracuse, they would have been as unintelligible as the chattering of a magpie. They were purely arbitrary or conventional; yet, much of our education had been devoted to their mastery. Nevertheless, as a means for expressing thought, they were, in the present case, quite inadequate. The ideas aroused in my mind were confused and fragmentary, and altogether unsatisfactory. The images lacked precision. Had my friend resorted to writing a description of the invention, in either English, French, German, Latin, or Greek, using in every case a set of purely conventional symbols (to represent the other set of conventional sounds), which we had both spent years in getting some knowledge of, he would have succeeded little better. Whether speaking or writing, much of his thought he could not clothe in words. He, therefore, abandoned the wholly conventional, or verbal, art of expression and turned to the pictorial.

But, here he soon confessed that his education was deficient. He had never studied the art of representing objects having three dimensions on a surface having but two, and hence he was ignorant of the methods he ought to adopt to express by drawings the objects he was thinking of. However, I caught more of his meaning from some crude attempts at sketching than I had from all his talk. A few lines were luminous with meaning; yet, they left far too much for me to supply by my imagination; hence, my visitor withdrew and sent me a full set of what we called "working drawings," made by the inventor, who was a draughtsman.

These drawings, though a sort of ocular resemblance to the things signified, were still half conventional, and required, on my part, a certain amount of training to enable me fully to understand them; this, fortunately, I had received, and, through the art of expression embodied in them, I gained a tolerably clear idea of the thought of the inventor. With scarce a written or spoken word, they expressed that thought far more clearly and fully than any merely verbal description could do; they showed the relations of parts which were beyond the reach of words.

But my friend was not content to stop there. The drawings had been but partially intelligible to him with their "plans, elevations, and sections," and, judging me by himself, he believed that a third art of expression would outvalue both the others; he, therefore, invited me to call at a shop and examine a specimen of the device itself, produced by a skilled mechanic. The *real article*, which is the mechanic's art of expression, proved to be an improvement even upon the thought of the inventor. The latter had not been a mechanic, and he had made the sort of mistakes that draughtsmen, who are not something of

mechanics, always make. Certain parts it had been practically impossible to construct, as they involved shapes that could not be molded by ordinary means. A nut had been placed where it was next to impossible to turn it; and certain parts which were to be of cast-iron had been given such dimensions that the castings would have snapped in pieces while cooling. These errors had been corrected by the mechanic, and the perfected thought lay fully expressed before me.

In this illustration we have three greatly different methods of expressing essentially the same thought. Each constitutes a distinct language, and each is absolutely essential to modern civilization.

You will note how a crude thought often takes practical shape in the hands of the draughtsman and the mechanic. "Drawing," says Professor Silvanus P. Thompson, "is the very soul of true technical education, and of exact and intelligent workmanship." Those who have tested this can tell how many marvels of ingenuity, as lovely as *châteaux en Espagne*, have vanished in the presence of "plans and elevations"; and how many beautifully drawn designs have been mercilessly condemned as impracticable by judges versed in the laws of construction and the strength of materials.

Much more could be said upon the arts of expression, their relative importance and proper cultivation. You will readily think, as did Lessing in his Laocoon, of poetry, painting, and sculpture. You will recall how lofty thoughts have in all ages found expression in architectural forms, and yet, throughout all the history of architecture, the laws of mechanics as then understood and the properties of the materials used have determined the different styles. In our own age we are trying to express ourselves in iron and steel, and to cast off the fetters of an age of marble and granite.

In a recent address Mr. Charles H. Ham, of Chicago, said that, by putting thought into seventy-five cents' worth of ore, it is converted into pallet-arbors worth \$2,500,000. He continues: "Skilled labor is embodied thought—thought that houses, feeds, and clothes mankind. The nation that applies to labor the most thought, the most intelligence (i. e., that best expresses its thought in concrete form), will rise highest in the scale of civilization, will gain most in wealth, will most surely survive the shocks of time, will live the longest in history."

But some one will say, as to methods of expression: "One art is enough for me; make me master of one, and I will care for no second." I answer, you are thinking of an impossibility. If a mechanic is only a mechanic, he is never a master, even of his own art. He is crippled at every turn; in expressing himself, he is limited to what he can make. He is without that powerful ally, drawing, the short-hand of the imagination, and in the presence of thoughts that baffle concrete expression he is dumb. Valuable machines even are sometimes purely imaginary. Clerk Maxwell, in his "Theory of Heat," says: "For the purposes of scientific illustration we shall describe the working of an

engine of a species entirely imaginary—one which it is impossible to construct but very easy to understand," referring to Carnot's engine. In like manner, if one would command confidence as a draughtsman he must be a mechanic as well. And, finally, if I am a student of words alone, and if I go not beyond my dictionaries, I shall never guess their meaning. A large proportion of our emphatic words are technical; they belonged originally to some craft, and none but a craftsman knows their exact meaning. President Eliot, of Harvard, once said that the highest education was that which gave one the fullest and most accurate use of his mother-tongue. I would modify the statement, and claim that the highest and most liberal education is that which, besides cultivating most fully the powers of thought, gives one full command of all the arts of expression.

I need not remark that many, perhaps most thoughts, do not admit of concrete nor even of pictorial expression, as, for example, all abstractions; hence they suffer seriously from want of clearness. If you have a clear thought on abstract matters you can never be sure you have expressed it clearly.

Before we devote ourselves exclusively to the arts of expression, we must cultivate all the faculties and encourage the growth of thoughts worthy of expression. The thought must precede its expression by any method, and in the cultivation of the thinking mind the concrete should precede the abstract. Give children clear and accurate thoughts of real things, of the material world we live in, of real plants and animals, of the laws of materials, of qualities and then of quantities, before you venture on the field of abstractions. Before you cultivate the high arts, make sure of the low ones; without them as a foundation no superstructure of fine art can stand overnight. As Emerson says (in "Man, the Reformer"): "We must have a basis for our higher accomplishments, our delicate entertainments of poetry and philosophy, in the work of our hands. We must have an antagonism in the tough world for all the variety of our spiritual faculties, *or they will not be born.*"

A habit of clear thinking once formed will never leave us, however abstract our investigations become; while a habit of stopping short with ill-defined results, of resting content with obscure and half-grown mental images, a mental attitude of fogginess, has a stultifying effect which seriously dwarfs the mind. This is a most important subject, but I have place for but a few words of exhortation. Give children clear thoughts, and begin with the concrete. When the mind is too weary or too sick to clear up obscurities, it is time to seek rest and recreation and fresh air. Beware of straining the powers of attention by too much schooling; beware of overtaxing the mind by too many and too difficult subjects, and especially beware of poisoning the blood and debilitating the brain by bad air. The fruit of any and all these evils is mental as well as physical decrepitude.

The Aims of Education.—But to return. I claim for these forms of expression, which I have taken pains to distinguish, more nearly equal care and consideration in the elementary education of every child. Teach language and literature and mathematics with a view to make each child a master of the art of verbal expression. Teach mechanical and free drawing, with the conventions of shade and color, and aim at a mastery of the art of pictorial expression. And, lastly, teach the cunning fingers the wonderful power and use of tools, and aim at nothing less than a mastery of the fundamental mechanical processes. To do all these things while the mind is gaining strength and clearness, and material for thought, is the function of a manual training-school.

Prejudices to be overcome.—The traditions are heavily against us, but the traditions of the fathers must yield to the new dispensation. As was to have been expected, the strongest prejudices against this reform exist in old educational centers.

As President Walker, of the New York Board of Education, frankly admitted at the laying of the corner-stone of Professor Felix Adler's splendid institution, "The Workingman's School and Free Kindergarten," the methods and aims proposed by the advocates of manual training-schools are a criticism upon the methods and aims of the established system, and nothing is more natural than for it to resent the criticism and discourage reform.

No man has done more—nay, no man has done as much—to introduce the manual feature into American education as Professor John D. Runkle, of Boston, and yet the School of Mechanic Arts established by him in connection with the Massachusetts Institute of Technology has, after an existence of several years, been apparently almost frozen out in the biting atmosphere of that highly æsthetic city. I doubt if one could find on American soil a more unpromising field for a manual training-school than beneath the lofty elms of Cambridge and New Haven.

Luxuries in Education.—There are luxuries in education, as in food and dress and equipage, and in wealthy communities the luxuries command the chief attention. At the English Universities of Oxford and Cambridge, a large proportion of the students expect to be gentlemen of leisure. The idea of giving heed to the demands of skilled labor, of preparing for lives of activity and usefulness—the idea of earning one's daily bread and of supporting one's family—scarcely enter their heads. Either they inherit livings, or they seek to get livings through the Church, or they enter the army with commissions purchased by kind friends who wish to get them out of the way, or they go into law or politics. It is no wonder that such men devote themselves largely to the luxuries of education—Greek, astronomy, philology, higher mathematics, Latin hexameters, Italian—in a word, to "polite" learning. In such an atmosphere as that how incongruous

is the plea of mine for an education to things; for a training of the hand and eye as well as the intellect to lives of useful employment! Yet half the colleges in the United States ape the English universities, and half the high-schools ape the colleges.

The result of all this has been a certain false æstheticism which turns away from the materialism of our new notions. The highly cultivated would soar away into purer air and nobler spheres. There is a feeling more or less clearly expressed that the material world is gross and unrefined; that soiled hands are a reproach; that the garb of a mechanic necessarily clothes a person of sordid tastes and low desires. As Dr. Eliot, of St. Louis, has expressed it, "It is thought to be a sad descent for a university whose aim should be the highest education to stoop to the recognition of handcrafts of the mechanic."

Manual Education.—Perhaps no better general statement of the new creed has been made than that of Stephen A. Walker, in a speech already referred to. He put it for us thus: "Education of the hand and the eye should go along, *pari passu*, with the education of the mind. We believe in making good workmen as well as in making educated intellects. We think these are things that can be done at the same time, and our proposition is that they can be done better together than separately."

As I said in the beginning, this proposition is meeting with general favor among the people. I have pointed out the sources of some of the opposition; it remains for me to touch upon the two objections which I surmise are about the only ones in the minds of my hearers. You ask first, "Is your proposition practicable?" You doubt the feasibility of uniting in a real school such incongruous elements as arithmetic and carpentry, history and blacksmithing. You fear either that the shop-work will demoralize the school, or that the shop-work will never rise above the dignity of a mere pastime.

Now, I claim not only that what I propose can be done, but that it has been done in St. Louis, and perhaps elsewhere as well.

Organization of a Manual Training-School. — Professor Thompson, in his valuable essay on the apprenticeship schools of France, classifies French technical schools under four heads:

1. The school in the workshop or factory.
2. The workshop in the school.
3. The school and the shop side by side.
4. The half-time schools.

To the first class the school is subordinate to the factory; the boys or girls learn a particular trade, and everything in the school as well as in the shop is designed to meet the wants of those expecting to enter the particular trade. For obvious reasons there can be no general adoption of such a combination in the country. Professor Thompson gives his verdict in favor of the school and the shop side by side, though there is much to recommend the second plan.

No one of the French plans exactly suits me. I prefer to incorporate manual with intellectual education, and include both under the name school. We do not have what you call school in the morning and shop in the afternoon; nor do we spend the forenoons with tools, and devote a few evening hours to study and recitation.

The Manual Training-School of St. Louis differs from all other technical schools with which I am acquainted. It much resembles the Boston School of Mechanic Arts, though it differs from it in admitting boys at fourteen instead of fifteen years of age; in having a three years' course instead of two, and in having a full and independent equipment of study and recitation rooms, as well as shops. I gladly avail myself of this occasion to publicly acknowledge our indebtedness to the able reports and papers published by ex-President Runkle on the Russian system of tool-instruction and the organization and work of his school.

Prospectus of the School.—A prospectus of our school has just been issued, giving in detail our course of study, and the methods of tool-instruction. I shall be happy to give a copy to every one who is sufficiently interested to ask for it. To those who do not care for the details, I will say that our course of study runs through three years, in five parallel lines:

1. A course in pure mathematics.
2. A course in science and applied mathematics.
3. A course in language and literature.
4. A course in penmanship and drawing.
5. A course in tool-work in woods and metals.

Our school is not managed on the assumption that all the boys who go through it will become mechanics, or that they will be manufacturers. Our graduates will doubtless be found in all the professions. We strive to help them find their true callings, and we prejudice them against none. I have no sort of doubt, however, that the grand result will be that many who otherwise would eke out a scanty subsistence as clerks, book-keepers, salesmen, poor lawyers, murderous doctors, whining preachers, abandoned penny-a-liners, or hardened school-keepers, will be led, through the instrumentality of our school, to positions of honor and comfort as mechanics, engineers, or manufacturers.

No Articles made for Sale.—For the purpose of discountenancing certain grave popular fallacies in this country, I will add a word, even at the risk of repeating what I have said elsewhere, as to our plan of shop management. We do not manufacture articles for sale, nor do we pretend to fully teach particular trades.

A shop which manufactures for the market, and expects a revenue from the sale of its products, is necessarily confined to salable work, and a systematic and progressive series of exercises is practically impossible. If the shop is managed in the interest of the student, he is allowed to leave a step or a process the moment he has fairly learned

it; if it is managed with a view to an income (and the school will be counted a failure if its income is wanting), the boys will be kept at what they can do best, and new lessons will be few and far between. In such a shop the pupils will suffer too much the evils of a modern apprenticeship.

"The common apprentice is a drudge set to execute all kinds of miscellaneous jobs. There is no systematic gradation in the difficulty of the exercises given him; more than half his hours are purely wasted, and the other half are spent on work unsuited to his capacity. What wonder that four, five, or six years make of him a bad, unintelligent, unskillful machine!" (Professor Silvanus Thompson).

A very bright boy of seventeen years had expected last fall to enter a pattern-shop in St. Louis as an apprentice, but was disappointed, there being no vacancy in the number of apprentices allowed. He therefore came to the Manual Training-School, and during the year made excellent progress, not only in carpentry and wood-turning, but in drawing, mathematics, and physics. When he showed me some of his handiwork at the end of the year, I asked him if he would have made equal progress as an apprentice. "No," said he, "I should have spent most of the first year sweeping out offices and running errands."

(Since the above was written, a gentleman told me of his father's experience when learning the trade of a tanner in Philadelphia, many years ago. He lived in the family of his employer, and during the first six months *he tended the baby.*)

Self-supporting Schools.—I fancy there is no more pernicious fallacy than this of making a school self-supporting by manufacturing for the market. Suppose you attempt to maintain one of these popular humbugs, a commercial college, on that theory, or to run a full medical school without endowment on the self-supporting plan (the students would probably write prescriptions cheap, and cut off legs for half price); or to manage a public school of oratory and English composition on the strength of an income derived from contributions to newspapers and magazines, and from orations made and delivered to order. Nothing could be more absurd, and yet the cases are closely parallel. No; do not be beguiled by the seductive promise of an income from the shop. Admit from the first the well-established fact that a good school for thorough education on whatever subject costs money, both for its foundation and its support.

Closely connected is the matter of teaching particular trades, to which the lads shall be strictly confined. Such a course may work well in monarchies, where the groove in which one is to run is cut out for him before he is born; but it is unsuited to the soil and atmosphere of America. A single trade is educationally very narrow, while their number is legion. "The arts are few, the trades are many," says Mr. Runkle. The arts underlie all trades; therefore let us teach them as

impartially and thoroughly as possible, and then it is but a step to a trade.

And this brings me to a very important point. Admitting that, with a suitable outfit of tools, shops, etc., a programme such as I have described can be carried out, you ask: "What, after all, is the manual training acquired at school good for? Has the mind been nourished through the fingers' ends? Has the hand gained any enduring skill? Is it really but a step from the door of the manual training-school to the shop of the craftsman?"

Experience answers all these questions satisfactorily, and adds that there is scarcely a calling in society that is not edified by manual training. Rousseau once remarked that "to know how to use one's fingers gave a superiority in every condition in life." I recently made systematic inquiry among the parents of my boys as to the effect of the one or two years' training in our school. Their reports on the points now under consideration are both interesting and encouraging. They write:

"Gerald takes great interest in fixing up things generally."

"Charles fixed my sewing-machine."

"George has made many little matters of household utility, and seems to delight in it."

"We go to Henry to have chairs mended, shelves put up, etc., and he does excellent work. He made a fine set of screen-frames."

"The mechanical faculty was quite small in John's case, and it has been developed to a remarkable extent."

"Leo does all the jobs around the house."

And so on, for nearly a hundred pupils.

Again, the parents testify to an increased interest in practical affairs, in shops and machinery, and in such books and periodicals as the "Scientific American." Beyond question, there is a certain intellectual balance, a good mechanical judgment, a sort of level-headedness, in practical matters consequent upon this sort of training, that in value far outweighs special products. Said Rousseau, in his "Emilius," one hundred and twenty years ago: "If, instead of keeping a boy poring over books, I employ him in a workshop, his hands will be busied to the improvement of his understanding; he will become a philosopher while he thinks himself only an artisan."

As to enduring skill, I will let you judge for yourselves. The blacksmithing has occupied the second-year class about two hundred hours—ten a week. Each man had his forge and set of tools, and each executed substantially the same set of pieces. Here is a partial set of the work done. The pieces are numbered in the order in which they were done. They were first wrought in cold lead while the order of the steps and the details of form were studied, and then they were executed in hot iron. I have a few of the lead specimens here. The boys have not yet learned to weld the lead. The instructor's estimate

of each piece is shown in the per cent stamped on it. The pair of tongs was made on time—less than four hours. On the day of our public exhibition, twenty boys worked at the forges about two hours. Practical smiths who were present highly commended their work. Their weakest point was the management of the fire.

Professor Clark wished me to bring some of the wood-work. I could easily have brought a cart-load, but thought it not necessary. The boys do not do fine work, of course, as these few specimens show. I, however, have tracings of the main exercises in wood-work.

As our school has seen but two years, I can not appeal to its graduates to answer the question, "How far is it from our door to positions as journeymen mechanics?" hence, I avail myself of the testimony of Mr. Thomas Foley, instructor of forging, vise-work, and machine-tool work, in the Boston Mechanic Art School. He had himself served an apprenticeship of seven years, and, after several years at his trade, had given instruction for five years. We must consider him a competent judge. In his report to Professor Runkle, and contributed by the latter to the recent report of the Secretary of the Massachusetts Board of Education, Mr. Foley says: "The system of apprenticeship of the present day, as a general rule, amounts to very little for the apprentice, considering the time he must devote to the learning of his trade. He is kept upon such work as will most profit his employer, who thus protects himself. . . . Now, it appears like throwing away two or three years of one's life to attain a knowledge of any business that can be acquired in the short space of twelve or thirteen days by a proper course of instruction." (I take it that by twelve days he means one hundred and twenty hours distributed over about forty days.) "The dexterity that comes from practice can be reached as quickly after the twelve days' instruction as after the two or more years spent as an apprentice under the adverse circumstances mentioned above."

Mr. Foley secures the best results from lessons only three hours long. He adds: "The time is just sufficient to create a vigorous interest without tiring; it also leaves a more lasting impression than by taxing the physical powers for a longer period. We have tried four hours a day, but find that a larger amount of work, and of better quality, can be produced in the three-hour lessons."

I consider this testimony of Mr. Foley very conclusive. It practically disposes of the claim, so often brought forward by practical men, that no boy can learn a trade properly without going to the shop at seven o'clock in the morning and making his day of ten hours, "man-fashion"; and that dirt and drudgery, and hard knocks, and seasons of intense weariness and disgust, even, are essential to the education of a good mechanic.

The Cost.—It remains for me to touch upon the second important question you all have in your minds, namely, that of the cost. You

are practical men and women, and you wish now to sit down and count the cost.

We set out in St. Louis to have the best of everything. We bought the best tools and put in the best furniture. We have plenty of room and light and pure air. We aim to have good teachers and all necessary appliances. Our capacity is about two hundred and forty boys, in three classes of one hundred, eighty, and sixty, in the first-year, second-year, and third-year class respectively.

Our building, complete, cost about	$33,000
Our tools and school-furniture	16,000
If we add the cost of the lot ($150 \times 106\frac{1}{2}$ feet)	14,400
We have, as the total cost of our plant	$63,400

Where land is cheap, and less or lighter machinery is used, less money would suffice, but let no one deceive himself by supposing that the reform proposed is to be at once a money-saving one. Such a school costs money, but it is a grand investment. Said one of our benefactors to me not ten days ago, "I feel better satisfied with the money I have put into the Manual Training-School than with any other money I have invested in St. Louis."

As to the cost of construction, the shop is about as expensive per hour as the recitation and drawing rooms. Good mechanics, fairly educated, who are at the same time endowed with the divine gift of teaching, are rare. We have a first-class machinist and an expert blacksmith, and pay each twelve hundred dollars per year. The size of our divisions is generally limited to twenty members—in drawing we shall occasionally "double up."

Incidentals—wood, iron, paper, etc.—and the wear and tear of tools amounted last year to about ten dollars per head. The total cost of supplies and instructions and all incidentals, next year, is estimated to be seventy-five dollars per pupil.

How then, say you, can this costly reform be accomplished? The public schools have no funds to spare; salaries are still too low, and the demand for extensions outruns the supply. As Colonel Jacobson, of Chicago, has said: "The alternative before you is more and better education, at great expense, or a still greater amount of money wasted on soldiers and policemen, destruction of property, and stoppage of social machinery. The money which the training would cost will be spent in any event. It would have been money in the pocket of Pittsburg if she could have caught her rioters of July, 1877, at an early period of their career, and trained them, at any expense, just a little beyond the point at which men are likely to burn things promiscuously. It is wiser and better and cheaper to spend our money in training good citizens than in shooting bad ones."

How to go to Work.—There are two ways of going to work:

1. Cut down somewhat, if necessary, the curriculum of higher

studies, and incorporate a manual department with your high-school. The investment will pay, and the means of further growth will soon be found.

2. Mature your plans and lay them before your wealthy, public-spirited men. Almost for the first time in America we are harvesting a splendid crop of millionaires. They abound in every city. They know that boundless wealth left to sons and heirs is often a curse, rarely a blessing, and they would fain put it to the noblest uses. In England such wealth would naturally go to the establishment of noble families, or the purchase of grand estates which should be transmitted unimpaired to the oldest sons through successive generations.

Our American peerage shall consist of those who devote the gains of an honorable career to the establishment of institutions for the better education of generations that shall come after them. Let others follow the example of Cornell, Vanderbilt, and Cooper, of New York; Stevens, of Hoboken; Girard, of Philadelphia; Johns Hopkins, of Baltimore; Case, of Cleveland; Rose, of Terre Haute; the Commercial Club, of Chicago; and those whom I could name in St. Louis.

A NOTE ON "THOUGHT-READING."

By HORATIO DONKIN.

AN article on this subject in the "Nineteenth Century" for June contains conclusions so inadequately supported by trustworthy facts that a few words of comment seem to be called for. The matter in question has attained a somewhat undue prominence of late; but if it is as simple and intelligible as it appears to be to most who have investigated it with care, and with minds free from mystical bias, any aid toward the extinction of what must then be regarded as an *ignis fatuus* of pseudo-science carries with it its own justification.

The position of the writers of the article seems to be that it is possible for one person to divine the thoughts of another in the absence of any *known* means of communication. This inference is based mainly on a series of statements of cases where several children of a certain family, as well as a servant-girl in the same family, were professedly able to tell words and objects thought of in their absence, without contact with or sign from those who knew what they were required to do.

It may be taken as proved that the explanation of *muscular indication* amply covers all cases where, as in the well-known drawing-room game of "Willing," there is actual contact between the person who guides and the person guided. It is difficult, indeed, for the guider, who is intent on the success of the experiment, to avoid giving

hints by pressure, alteration of speed, and otherwise, to the guided one, who is, as a rule, only too ready to quickly interpret them. The same explanation would apply to cases where the person who is "willed" to find something hidden during his or her absence is in no contact with any of the "willing" party, but who often succeeds in discovering the desired object by studying the unconscious indications given by the faces of the expectant circle. All this is, in fact, nearly admitted by the writers we quote, though their denial of Mr. Stuart Cumberland's own explanation of his performances in this line is perhaps as unwarrantable as the "further inquiry" that they suggest.

The remarks in this paper will, therefore, be confined to the alleged results obtained where there was no actual contact. It will be at once admitted with the writers of the article that common sense demands that every known mode of explanation of facts should be exhausted before the possibility of an unknown mode is considered. This is an all-important admission, obvious as it seems to be. It is required by the method of common sense, which is no less the method of science; all true explanation consisting in a procedure from the known to the unknown.

In the next place, it is equally obvious that in all scientific inquiries the good faith of individuals concerned should form no part of the data on which the conclusion is to rest. A person merits credence in proportion as the facts he alleges can be demonstrated or reproduced, and to the jealous care he shows in avoiding fallacy. But we can never, as our authors say, call on Science to put deception out of court by a belief in any one's integrity. Half of the evidence which has propped up the spiritualistic craze is based on the results obtained through mediums of "unblemished character" in private families, whose virtuous reputation has been largely sustained by the fact that they did not take money for their trouble; no regard being paid to innumerable other motives and tendencies to deception.

This being admitted, the cases before us in the paper alluded to can be easily dealt with. They differ in no way from the ordinary platform performances of the little "clairvoyantes" who from time to time have amused us both in the name of Second-Sight and in that of the humbler and honester one of Conjuring. It is well known that a very simple code of signals will suffice to produce results much more startling than those we are discussing. The first word or letter, for instance, of the question asked of the "sensitive" medium may denote the category to which the object fixed upon belongs. The second and third, and so on, serve to specialize it further, and by a series of questions and remarks it is easy to understand that any amount of information may be conveyed. When the clairvoyante is not blindfolded, other means of communication, of course, are possible, and in any case auditory signs other than words could be

agreed upon quite unsuspected by the audience to be amused or deceived.

We have, therefore, an intelligible and admitted explanation which fully serves to cover all the facts in question. Such things are constantly done by collusion—it is a *vera causa.* It would be illogical to substitute for this a perfectly gratuitous hypothesis and an unknown agency. This is especially true in the case of such a set of phenomena as we are now considering. The possibility of thought-reading, as alleged by the writers of the paper, is so far beyond, or rather contrary to, universal experience that some use might fairly be made of the *a priori* argument, although the case need in no way rest on such a method. It may be said in passing that there is an enormous *prima facie* objection to the truth of the proposition that such divination is possible: the assumption and conviction of the contrary, based on immemorial experience, being, as it were, one of the suppressed major premises of all social intercourse.

On this argument, however, we would not depend unduly. The case against the genuineness of the asserted phenomena seems strong enough without it.

The children in question were *not* blindfolded.

In most of the experiments *there is no mention made of silence being preserved.* On the contrary, we may infer that no such rule was made; as the children must have been corrected when their guesses were wrong, as they often were.

On the hypothesis of collusion, it must further be noted that, in order to minimize the difficulty of the code of signals, and simplify the performance as much as possible, the child was previously informed of the nature of the object selected—e. g., whether it was a card or a name. The first guess, then, would give an opportunity for the conveyance of perhaps even the final hint contained in the correction offered.

The mistake made by the *servant* in guessing the name "'Enry" for "Emily" is obviously significant, and an excellent example of an "undesigned coincidence." Surely it must lead almost every plain mind to the irresistible conclusion that a mistaken whisper or facial gesture played some part in the phenomenon. This remark applies as well to the errors made by the children in the case of words alike in *sound.*

The theory of collusion is, moreover, strongly countenanced by the fact of the mediums being children, who are always ready to join in any game of deception; and by the association with them of the servant-girl—a valuable fact, putting out of court the assumption of any inherited special quality peculiar to the family, as an explanation, possibly plausible to some minds, of the alleged marvels.

It will probably, however, be readily allowed, with the authors of the article, that the experiments made in the presence of the members

of the family are scientifically untrustworthy. They may, therefore, be practically ignored. Yet we infer from the paper that most of the experiments were made under these conditions; and we read that the presence of the father "seemed decidedly to increase the percentage of successes."

The authors, indeed, say, "Though generally the object selected was shown to the members of the family present in the room, we were sometimes entirely alone." From the only rational point of view, that of scientific skepticism, and therefore with total disregard of the personal factor, this consideration seems in no way to invalidate the line of comment here taken. It is not clear to how many of the three observers the pronoun "we" in the above passage refers; but, at any rate, we miss entirely in the paper any specific quotation of results obtained in this latter set of circumstances.

But, even if this evidence had been forthcoming, no mere *ipse dixit* on such a matter could for one moment be admitted. Reason would require us to entertain the great probability of mental bias in some at least of the observers, or to discredit the accuracy of their memory, rather than to allow that anything has been adduced in this account of what, to say the least, must be called superficially conducted experiments, to warrant a recognition of any novelty, or, by consequence, to stand in need of explanation by a theory of "brain-waves."—*Nineteenth Century.*

THE PHYSICIAN OF THE FUTURE.*

By Professor GEORGE H. PERKINS.

A CHANGE in the theory of disease, which long since began, but is not yet completed, must profoundly affect the work of the physician of the future. Disease was formerly believed to be a something which had a sort of independent existence, and which went about over the earth seeking whom it might assail. When this something had entered the body of a man it created confusion in his internal economy, and order could not be restored until the intruder was driven out. Accordingly, remedies none of the gentlest were vigorously applied until the disease was scared away or the patient died. It is strange how universal among men this belief in a possession, an entrance of something into the body causing disease, has been.

This savage idea was long perpetuated among civilized people, and remedies were used which were hardly less absurd than the leapings, howlings, and rattle-shakings of an Indian medicine-man. The change

* An Address delivered at the opening of the Twenty-ninth Annual Course of Lectures in the Medical Department of the University of Vermont.

has come very gradually. At first the student of medicine enlarged his field of study, from disease and its phenomena, until it included the structure and action of tissues and organs in health. Physiology and anatomy, of little importance in the old science of medicine, began to have recognized value. After this it was found that organs did not always become disordered because of assaults from within the body, but that they were affected by external influences.

It was found that the organs must not only preserve equilibrium within the body, but that there must also be equilibrium between the body and its externals. It was discovered that in every organ there were forces that built up and forces that pulled down, and that outside of it there were also conservative and destructive forces, and it became obvious that, unless these acted so as to preserve equilibrium, disease, and finally death, must ensue. Thus the art of healing and the science of medicine are now very far from being as simple as they were a century ago, and every year adds to their complexity. The physician of to-day must have full knowledge of man as man, of anatomy and physiology, as a necessary foundation upon which his further studies must rest.

Physiology especially has developed during the last fifty years, so that it has almost become a science by itself, but it still remains a part of the wider science of biology. Here again we see a difference between the studies of the ancient and modern physician. To-day, and still more in the near future, the physician must extend his studies beyond man, and the reason is plain. Man, with whom alone the physician formerly supposed himself concerned, is but an isolated being disconnected from the rest of nature. Nature tolerates no such isolation. No living being, even the simplest, exists, or can exist, independently of other beings. It affects them and is affected by them, and what is true of the simplest is yet more true of the more complex and most of all of man. Nature is one, and all her creatures are parts of the whole. For this reason man can not be fully known merely as man, he must also be known as a part of the animal kingdom. No one can well understand human anatomy or physiology who knows nothing of that of the lower animals. Comparative anatomy and physiology have thrown very much light upon many obscure problems to which the study of man gave rise. Therefore, I would most earnestly urge upon all medical men the study of biology. It may be replied that the courses of study are now crowded, but it is certain that the successful physician of the future *must* know something of nature as a whole. Already many of our most important theories as to disease—the structure of organs, cell-growth, cell-life, and many more—have come to medicine from biology. In an address before the International Medical Congress held in London in August, 1881, Professor Huxley remarks that "the search for the explanation of diseased states in modified cell-life, the discovery of the important part played by parasitic organisms in

the etiology of disease, the elucidation of the action of medicaments by the methods of experimental physiology, appear to me to be the greatest steps which have ever been made toward the establishment of medicine on a scientific basis. I need hardly say, they could not have been made except for the advance of normal biology. There can be no question, then, as to the connection between medicine and biological science. There can be no doubt that the future of pathology, of therapeutics, and therefore of practical medicine, depends upon the extent to which those who occupy themselves with these subjects are trained in the methods and impregnated with the fundamental truths of biology. And I venture to suggest that the collective sagacity of this congress could occupy itself with no more important question than with this: How is medical education to be arranged, so that, without entangling the student in those details of the systematist which are valueless to him, he may be enabled to obtain a firm grasp of the great truths respecting animal and vegetable life without which, notwithstanding all the progress of scientific medicine, he will still find himself an empiric?"

The modern theories of evolution have done great things for medicine, and will do far more in the future. They have put in action forces that may revolutionize medical science. Evolution has shown, as nothing else could, how profoundly animals are affected by their environment, their food, habits, climate, etc., and, by showing how inevitable is the modification of structure in other animals, has called attention to the same facts in man's existence.

Men knew long ago that animals were greatly affected by their surroundings, but this truth was far from being fully recognized until evolution re-affirmed it, and emphasized its affirmation by facts which could not be passed by. Thus man was led to ask, What application have these principles to my own habits of life, to my well-being? To what extent are my diseases induced and fostered by external conditions? The reply to these inquiries is found in sanitary science, in health officers and boards of health, and we have as yet only the beginning of the answer. Sanitary science, though in its infancy, has already profoundly affected medical science in many directions. Perhaps the most important effect that as yet appears is the leading medicine away from its old, blind, absolute faith in remedial agents, in therapeutics, toward greater faith in right living, proper diet, dress, and drainage. Not that remedies are to be wholly laid aside, but they will be more sparingly used, and more intelligently, and often not at all. Where formerly drugs, powerful in quantity and quality, were invariably given, many of our best physicians now prescribe few or none, depending, and with better results, upon pure air, simple food, and other hygienic means. I believe that more would thus treat disease were they not prevented by the patients themselves.

So long as it is less trouble to take quinine than to clear out drain

or cess-pool, so long as men prefer swallowing drugs to abstaining from favorite articles of food, or regulating personal habits, so long must the medical advisers of a community find their best efforts to advance sound sanitary science thwarted. It will be a long and tedious task—this of educating out of the popular mind this strange passion for dosing; but herein lies one of the most important tasks of the physician of the future. If he does his work well, he must be strong enough and determined enough to stem a powerful current of deeply rooted prejudice and self-indulgent unreasonableness; but, if he and his fellows only persevere, they will do incalculable good. So difficult is this work that many shrink from it. They admit the importance of fresh air in hospitals, nay, they demand it, but in their private practice they say little about ventilation. They are careful that their prescriptions shall be properly compounded and regularly taken, but they are much less careful about the diet of their patients. They treat zymotic diseases, but do not enforce such sanitary regulations as they know to be necessary. I do not say that all are open to this charge—not all, but some—and there should be none. With all earnestness would I plead that the people be taught how to live, and I would urge this not only for the sake of the people, but for that of the doctors as well. It is evident that their success as healers of disease must be far greater if their patients observe hygienic laws than if they do not. The instructions of the doctor, weighty enough when given to one stricken with grave disease, may often fall unheeded upon the listless ears of a well person. Sick people are usually more eager to get well than well people to avoid sickness; and yet, even though the labor seem well-nigh useless, the welfare of the race demands that the principles of hygiene be made known, and the task of doing this naturally rests upon those who have undertaken to be the medical advisers of the community. It may be that the people will learn to care very much for those laws upon the observance of which good health depends, with discouraging slowness, but the good work once begun must go on with increasing power and influence. We may take heart as we see what has already been done in this direction, for a great deal of very important knowledge has already been received by the people—knowledge of the necessity for fresh air and sunshine, of cleanliness of person and of premises, of proper food, clothing, and exercise, of the laws of heredity and how hereditary tendencies to disease may be overcome. If we compare the sanitary condition of the homes and the villages of our ancestors not more than a century ago, with that which we may now find, we shall, I think, be led to hope very much for the future. It may still be true, as an eminent medical writer not long since declared it to be, that "men in general behave in relation to the laws which govern human evolution very much as primeval savages behaved in relation to the laws of physical nature—are content with superstition where they should strive to get knowledge, and put up

prayers where they should exert intelligent will." This may be true, but it is certainly less true than formerly, and the physician of the future is to see to it that it becomes wholly untrue. If man can ever reach a time when epidemic diseases shall be of rare occurrence, when all zymotic diseases shall be confined within narrow bounds, and be speedily eradicated within these, he must remember with profound gratitude those to whom he owes his happy estate. Is there any other way in which the physician can so alleviate suffering and so help mankind as by striving to bring to pass such a blessed state of things? Is this too much to hope for? Possibly, but we may approach it much more nearly than we have as yet. Even in its beginning preventive medical science is far from a failure. Epidemic diseases that once raged as the pestilence are now largely prevented; others, once objects of unspeakable terror, are robbed of much of their virulence. Life-insurance statistics show us that human life in England is more than thirty per cent longer to day than it was one hundred and fifty years ago, and the end is not yet reached.

The relief of suffering, which is commonly thought to be the chief mission of the physician, is indeed a great and noble work, but I believe that he may do a higher and grander work. There are a pathology and a morbid anatomy, not of the body only, but of the moral nature as well. Many physical disorders are also moral and mental, and can only be rightly treated as this is understood. If it be true that men are not only more comfortable and happy when well than when ill, but that they are better morally, a new and most important field of usefulness is opened before the physician. If a well man, other things being equal, is a better man than a sick one, more certain to act wisely, to judge candidly and fairly, and live rightly—if a well man is of more worth in every way than a sick one—then all that has been said of the need and the value of hygienic instruction has added force. I do not for a moment forget the many heroic natures that have been grand enough to rise above bodily pain and feebleness, and with pathetic earnestness have sought to do some good work for the world, and have sent forth from their chambers of suffering golden words, melodious, heart-stirring verses, helpful soul-inspiring thoughts. And yet we need to recognize the fact that good is more certain to come from health than from disease. Pain may have its mission, physical and moral, and may bring out the richness and sweetness of a character as nothing else can, but in and for itself it is not desirable, and it can not be doubted that a community that is sound physically will be more sound morally than it could be if harassed by pain and weakness. I believe that there is such a thing as sin in the world, and I would not call it a disease for which man is not responsible; but none the less do I believe that physical disorder, that sickness and pain, morbid conditions of the body causing morbid conditions of the mind, may and do lie at the foundation of very much that we call crime. A man

whose digestive system is a continual scourge, whose nerves are weak or excited, whose brain receives impure blood, such a man *can* not be the same man morally that he would be were he in full vigor of health. Well men are not always virtuous. Ill health is not the sole cause of crime, nor can criminals be treated as invalids—not at all. And yet crime is often closely connected with disease. It is often both the parent and the offspring of disease. Since we may not know just how much of the crime in the world is due to pathological conditions of the body, we must punish crime as such, but we may, because of our doubt as to its cause, be liberal with our charity and lenient in our judgment whenever, and to such extent, as they may not interfere with the welfare of society as a whole.

No one holds a maniac morally responsible for his actions, even if grossly criminal. Is insanity the only morbid condition that dwarfs man's moral instincts, that blinds him to truth?

In this case we can see how much preventive measures are better than curative, and the future work of the physician, if it be largely the teaching people how to live so that they may avoid disease, must also lessen the amount of crime. It were well if the physician kept constantly before his mind the thought that he is to seek to make men better morally as well as physically. If it is better so to live that illness shall not come, than being ill to be cured, it is also a nobler and a higher task to prevent disease than to heal it, and in this labor of prevention medicine will rise to a height far above that to which it has yet attained, and accomplish results more beneficent and glorious than its greatest triumphs of the past.

And the whole community must be instructed—women more than men, for they more than men regulate the condition of the home. Upon them is laid not only the burden of bearing the children, but they most have to do with their food, clothing, and general training. And, since woman must take part in the great work of sanitary instruction, she should have a thorough medical education, that she may be able to tell to every woman, and every girl too, what she ought to know, and what she will not and can not learn so readily nor so well from any man.

If man were altogether an animal and had only animal instincts, there would perhaps be little ground for hope, but man can be taught not merely that he may so care for his body that it shall be less subject to the attacks of disease, he may be taught that it is his duty to so care for it that his physical organism is a God-given trust which he can not violate without moral wrong. The physician of the future must, as has been already noticed, have to do with the moral as well as the physical nature of man. But, before he can do this with success, he must understand what man is, his feelings, emotions, thoughts, as well as the course of the blood or the action of organs. If he shall know of this higher part of man, he may appeal to it forcibly and

persistently. Anatomists and physiologists, as they study the body, may be so engrossed in the object of their investigations that they forget that it is not the whole of man. They may forget that this dead body which they study does not offer any explanation of the deepest and most conspicuous phenomena of human life and experience. The cadaver on the dissecting-table is not a man. Neither the anatomist's scalpel nor the histologist's microscope can ever discover what it was in that body which made it a man, distinct from other men.

The lips, tongue, vocal cords, are all there, but it was *by* these, not from them, that came the words of love or hate, entreaty or command, which the man spake during his life. The brain is there, it is or was the organ of the mind, but the thought—where is that? Evidently we have not here all that made this man a man, and we must see more than the body if we are to know man; we must see that in that body there was an essence—a something which we can not define, but which is as real as if most definite, and that this something, this soul, is far more important than any other part of man. When he stands over his dissecting-table, the anatomist may think of man as only an aggregation of organs and tissues, and these of differently arranged and modified cells; but when he sends his thought into the recesses of his own heart, when he calls before him the experiences of his inmost life, when he looks around him and sees men—their activities, struggles, defeats, triumphs, courage, even their meanness and knavery, and still more when he knows of their thoughts of the hereafter, their longings for something better and higher than this world can afford them—when, in short, he stands face to face with the phenomena of human life in its varied phases, is he not compelled to believe that it all must have some other source than the molecular and chemical forces which he finds in the body?

It is in this fact—in the existence of a soul in man—that the physician of the future must rest his hope of success. That man has in himself capacity for growth, that progress is and always must be possible to him—these are truths that must sustain the sanitary reformer in the midst of greatest discouragement. If it be true that man may live not only for the present, but as well for the future; if he can be made to see that he may not only make his present life better and nobler, but that in doing this he is affecting his future life; if he can be brought to understand that what he is in this life must necessarily determine largely what he is to be in the life beyond the grave; that, though the body is not the soul, yet, as the medium by which the soul manifests itself, its condition affects the soul—will he not be ready to listen to the teachings of any who can help him to a better physical and so to a better spiritual life? Only as the physician holds before his mind the whole of man can he reach the full development of his own life; only thus can he raise man to that height of sanitary well-

being to which he should seek to raise him. In the address to which reference has already been made, Professor Huxley says: "A scorner of physic once said that Nature and disease may be compared to two men fighting, the doctor to a blind man with a club who strikes into the *mêlée*, sometimes hitting the disease and sometimes hitting Nature. The matter is not mended if you suppose the blind man's hearing to be so acute that he can register every stage of the struggle, and pretty clearly predict how it will end. He had better not meddle at all till his eyes are opened." This predicament of the blind man is probably not unfamiliar to every doctor, for at best human skill and knowledge often reach their limit before the disease does, but certainly every physician should be ready to exert himself to the full extent of his power to open his eyes as far as possible, to be as little blind and as seldom as may be. And as a blind man may be able to prevent a conflict which, once begun, he can not control, so the doctor may have sufficient knowledge to prevent disease which he can not heal. He may often be more certain of his position as a preventer than as a healer of sickness.

Although man stands at the head of creation, it does not necessarily follow that he has reached his highest possible position. It seems entirely reasonable to believe that a more thorough dissemination of sanitary knowledge and its more complete application in common, every-day life would develop a race of men longer-lived, more vigorous, happier, and better than any yet seen. It may be too late to do very much with this generation, but may there not be hope for the next, and the next after that? What might not a few generations of right living, right feeling, right thinking men do for the race? Here, then, are opportunities within the grasp of the physician of the future such as await no one else—opportunities for useful, helpful work such as never before inspired the mind or stirred the heart of the professional student; such a privilege of effectually aiding in the advancement of the human race, of making it nobler and better.

Such opportunities well used must bring upon those to whom they are given a glorious benediction.

It should not escape the notice of the physician that this golden future will not inevitably be his to whom by right it belongs. By right, if he seizes it and holds it; but, if he does not, it must slip from him, as it should. Already many of the leaders in sanitary movements are not from among medical men. These, many of them, fail to appreciate their privilege; they do not see what is before them, but are so busily engaged in search of some pill or potion which may or which may not cure some disease, that they can not see the treasure which lies just within reach. The whole work of medicine is important, and the search after remedies should not be abandoned as useless, neither should it take the place of greater and more important labors. It is a noble thing to give time and strength to the discovery of means

which may be used to heal disease or alleviate pain, but it is a far grander and nobler task to teach the people how to live so that disease and pain will not come upon them.

TRIALS BY FIRE AND FIRE-JUGGLERS.

By M. A. De Rochas.

IN his very interesting lecture on witches, Dr. Regnard has mentioned that insensibility to suffering was, in the middle ages, considered evidence of diabolical relations. By a singular contradiction of the human mind, this same insensibility was also under certain circumstances attributed to divine intervention; and that which, in one case, brought death upon the accused, was good for his acquittal in another case.

Trial by fire, by means of which Heaven was appealed to for proof of innocence, appears to have originated in India. The Vedas mention it, and travelers still find it in use in all the East. The Greeks also were acquainted with it. "We are ready to hold red-hot iron and walk through flames to prove our innocence!" exclaimed the Thebans in the "Antigone" of Sophocles, who were accused of having abetted in the theft of the body of Polynice.

The first authentic trial of this kind recorded among Christians is related by Gregory of Tours, in the case of Saint Sulpicius, Bishop of Autun. This saint, who lived in the fourth century, was made a bishop, although he was married. His wife could not make up her mind to leave him, but resolved to live with him under a vow of chastity taken according to the laws of the Church. Having learned that the faithful accused them of not observing their vow, the woman had fire brought to her publicly on Christmas-day, and, having held it in her dress for nearly an hour, gave it to the bishop, saying to him, "Take this fire, which will not burn you, so that they may see that the fire of lust has no more effect upon us than these coals have upon our clothes."

Saint Brice, Bishop of Tours, made use of a similar trial to prove his innocence of a crime that was imputed to him. The chronicles, beginning from this epoch, have preserved numerous examples of these trials. They were employed, not only to discover heretics, but also to distinguish genuine relics from false ones. The Council of Saragossa, in 592, ordered that only those relics which the fire had respected should be venerated. The multiplication of these trials in Gaul was probably due to the influence of the conquering race, with whom the custom seems to have been established from time immemorial. In an addition to the Salic law made by Kings Childebert and

Clotaire, in 593, was a clause that a man, accused of theft, should be adjudged guilty of it if he was burned in the trial by fire. In 630 King Dagobert, in reforming the laws of the Bavarians, the Alemans, and the Ripuarians, according to Christian ideas, continued in effect the law of the Ripuarians providing that, if any one was cited before a court to answer for an offense by his servant, he should be adjudged guilty if the hand of his servant was hurt by the fire. In 819 Louis le Débonnaire ordained that a servant, who was burned in the trial by boiling water, should be put to death. Hincmar relates that Queen Thietberge, wife of King Lothair, when accused of a horrible offense, proved her innocence by a man who underwent for her in 860 the trial by boiling water without being scalded. In 876, Louis, second son of Louis the German, established his rights over Germany, which his uncle, Charles the Bald, contested, by means of thirty men, ten of whom suffered the trial by cold water, ten that of hot water, and ten that of red-hot iron. Charles the Bald, not willing to give up to these proofs, marched against his nephew at the head of an army, and was thoroughly beaten. It would be superfluous to multiply examples of this kind, which became more and more numerous till the end of the eleventh century, when the trials were formally condemned by Popes Stephen V, Celestine III, Innocent III, and Honorius III.

We pass on to the description of the general course of proceeding: Trial by hot water was made simply by plunging the arm into a boiler full of boiling water, to take out from it a ring, or a nail, or a stone, which had been suspended in it. In some causes the hand was put in to the wrist, in others to the elbow. It is even said, in the formulas of Saint Dunstan, that the stone was sometimes concealed under an ell-deep of hot water. Commoners made the trial for themselves, while people of quality hired others to make them. Those who were burned were declared guilty, and those who escaped were considered innocent.

The trial with hot iron, called judgment by fire, was made in different ways. Sometimes one red-hot iron was taken hold of—or perhaps several in succession—and was carried to a considerable distance. The iron was generally shaped like a plowshare, and was, therefore, called *Vomer*. A second way was to walk upon red-hot irons with the legs bare to the knee. Six, nine, or twelve irons were made ready for the trial, according to the magnitude of the imputed offense. In Denmark a kind of red-hot iron glove, reaching to the elbow, was used.

The trials were made in the presence of priests delegated by the bishop, and of secular officers of justice. Those who submitted to them were obliged first to wash their hands, arms, or feet, with fresh water, to remove any advantages they might have obtained from rubbing their limbs with some substance that could deaden the action of

the fire; the priest then threw holy water upon them, pronounced exorcisms and benedictions, which may be found in the formulas of Marculfe and Saint Dunstan, made them kiss the Gospels, and then the trial began. When it was over, the hand, arm, or foot that had been in contact with the fire was wrapped in a linen cloth, under the seal of the judge, not to be opened till after three days had passed.*

It is not easy to give now a natural explanation for all of these facts; we are too little informed respecting the accompanying circumstances. It appears, however, that we might, besides having recourse to the cases of hysterical insensibility described by Dr. Regnard, connect the power of enduring the trials with one of the three following causes: diminution of the sensation of heat by evaporation from the surface of the skin; insensibility obtained for the skin by means of preliminary artifices; and illusion respecting the intensity of the source of heat.

With respect to the first of these causes, the experiments of M. Boutigny are well known; and it is possibly only the want of hardiness that prevents our discovering more numerous applications of it. Dr. Davenport, an English physician, gives one of them. He says he has seen a workman in the dock-yards at Chatham plunge his bare hand into boiling pitch. The man tucked up his shirt-sleeve, put in

* [A volume of the "Calendars of State Papers; Colonial Series," recently published in London, under the editorial supervision of W. Noel Sainsbury, of the Public Record Office, contains in a letter of 1620, from an agent of the East India Company, in the Island of Tecoe, a description of the native rite of purgation from the charge of murder, which closely resembles the Saxon ordeal. The account is the more valuable and interesting, because it is, to all appearance, authentic, and not tainted with the superstitious credulity with which the stories dating from the middle ages are colored. An Englishman having been killed by some of the islanders, Nicolls, the chief factor, obtained their king's license to summon the suspected persons and make them touch the corpse. All except one, who was ill, obeyed the summons, but betrayed no sign of guilt; whereupon the king ordered the absentee to be sent for. "He took," says the narrator, "the dead man by the hand with extreme quaking and many distracted gestures and answers, but would not hold it any time. Nicolls urged this to be the man, and required justice. The king caused him to be bound, and professed in his conscience that he was the man, but that he must be tried by their law also. . . . A fire was made, and an iron pan with a gallon of oil set to boil, till it came to such a degree of heat that a green leaf dipped therein was sodden and shriveled. The prisoner was then, in testimony of his innocence, to take a small ball of brass, little bigger than a musket-shot, out of the oil with his naked hand, and if any burning or scald appeared thereon he was contented to die. . . . Stripping up his sleeve above the elbow, and taking a kind of protestation, desiring that as he was clear he might prosper in this act, he dipped his hand to the wrist in the boiling oil, took out the ball, held it fast, and crying '*Olla Basar!*' ('Great is the Lord!'), tossed it up, caught it again, and then cast it on the ground, showing his hand, which had no more sign of hurt than if he had experimented the same in cold water; the devil, as seems, being loath at that time to lose his credit. The fellow was instantly released, and within an hour after returned in his holiday apparel, and none so lusty as he, though so weak before as to be brought upon men's shoulders to his trial. This was all the justice we could have for our murdered man."—EDITOR P. S. M.]

his hand up to his wrist, and took out some of the pitch as he would have done with a spoon; the pitch, which was in actual contact with his skin, he wiped off with tow. To assure himself that there was no trickery, Dr. Davenport put his whole forefinger into the boiling pitch, and was able to move it about for some time before the heat became uncomfortable. The workman affirmed that, if any one put his hand when covered with a glove into the boiling liquid, he would be burned very badly. A fact related by Dr. Beckman, another physician, is referable to both the first and the second of the causes we have mentioned. A workman in the foundry at Auerstädt, in 1765, for a small gift, took some melted copper in the hollow of his hand, showed it to the spectators, and then threw it against the wall. Then he rubbed the fingers of his calloused hand briskly together, put them under his armpits for a few instants, to make them sweat, as he said, passed them over a dish of melted copper as if he would skim it, and finished by moving his hand rapidly backward and forward in the liquid mass. Dr. Beckman perceived a strong smell of burned horn while this was going on, but the man's hand did not seem to be hurt.

In 1809 a Spaniard named Lionetto went through Europe performing still more wonderful feats. While he was at Naples he excited the curiosity of Professor Sementini, who made a study of him, and, having performed numerous experiments upon himself, has left us the most positive documents that we possess on the subject. Lionetto put a plate of red-hot iron on his hair, and a thick fume was immediately seen to rise from it. He struck his toes with another red-hot iron, and this likewise produced a thick and offensive vapor. He put an iron nearly red-hot between his teeth. He drank about a third of a spoonful of boiling oil. He quickly plunged the ends of his fingers into melted lead, and put a little of the liquid metal on his tongue; and afterward he bore a red-hot iron upon that organ, which was covered with a grayish coating. Professor Sementini discovered: 1. That rubbings with sulphuric acid leave the skin insensible to red-hot iron. 2. That a more complete result is reached by rubbing with a solution of alum evaporated till it becomes spongy. 3. That the insensibility obtained by either of these processes is made considerably more perfect by a series of rubbings with hard soap, each rubbing, except the last one, being followed by washing with water. 4. That the tongue may be made insensible by covering it with a salve composed of a solution of alum saturated at the boiling-point. Boiling oil put on a tongue thus prepared did not burn it; a hissing was produced, like that of hot iron when put into water; the heated oil cooled in contact with the solution, and could then be swallowed without danger.

Professor Sementini remarks that Lionetto, to satisfy the spectators that the oil was really hot, threw lead into it, which melted, but that the lead, in melting, absorbed a part of the heat from the oil. It is very possible, also, that the jugglers, instead of melted lead, used

alloys fusible at low temperatures, or even simply mercury, as is done in some imitations of their tricks.

A father in the Church, Saint Hippolytus, has revealed to us in a book called "Philosophumena" other tricks which the pagan priests employed. "This is the way," he says, "that the magician can put his hand into a brass vessel full of pitch that appears to be boiling. He puts into the dish vinegar and natron (carbonate of soda), and, on top of this liquid, pitch. The mixture of vinegar and natron has the property, on the application of the slightest heat, of agitating the pitch and producing bubbles that rise to the surface and present the appearance of boiling. Previous to the operation, he washes his hands several times with salt-water, which would keep them from getting burned even if the pitch should be really hot. If he anoints his hands with myrtle, natron, and myrrh mixed with vinegar, and washes them as well with salt-water, he will not be burned. His feet will not be burned if he anoints them with isinglass.

"The magician breathes fire and smoke from his mouth; then, putting a piece of cloth on a dish full of water, he throws burning coals upon it, and they leave the cloth intact.

"He breathes smoke from his mouth for a short time, by putting in it a coal of fire wrapped in tow, and keeping the coal alive with his breath. The cloth in the dish is kept from being set on fire by the coals that are thrown upon it, by the transfer of the heat to the salt-water under it. The cloth should also be previously dipped in salt-water and covered with a mixture of whites of eggs and liquid alum. If to this liquid we add the liquor of eternal life,* the effect of the composition is to render the cloth—providing it has been prepared for some time—wholly incombustible."

We may remark upon the similarity of the last recipe with that which the latest experiments have suggested for the robes of ballet-dancers in the opera.

The feat of breathing fire played an important part in antiquity. By its aid the Syrian Eunus was able to revive the insurrection of the slaves in Sicily, and Barchochebas to assume the command of the Jews who revolted against Hadrian. Both used it to make their followers believe in the divine inspiration with which they pretended to be invested, the former by the Syrian goddess, the latter by the God of Israel.

I give next one of the recipes of the jugglers who at present perform this miracle in the fairs. They take a handful of tow in each hand; the left hand holds also, concealed, a piece of burning tinder. The performers begin by taking from the right hand with the teeth a piece of tow which they pretend to chew, while they fill it with saliva and dispose it in the mouth, by the aid of the tongue, so as to form a

* Possibly ammoniacal carbonate of copper, the magnificent color of which is called by chemists celestial blue. The ancients got ammonia by distilling blood with ashes.

kind of shield against the heat. Then, pretending to take new tow with the left hand, they introduce into the mouth the parcel of inflamed tinder, on which they immediately place dry tow by biting into the right handful. Combustion is excited by blowing with the throat, and the current of air protects the lips from burning.

I have repeated the experiment of a pretended boiling described in the "Philosophumena," using oil instead of liquid pitch. It produced a complete illusion. The oil boiled in large bubbles, throwing up to the surface a white foam, without its being necessary to raise the temperature to more than 86°.

I have not tried either of the processes for producing insensibility described above, nor those which are given by Albertus Magnus and other sorcerers of the middle ages, as follows:

"1. Take mallows-juice, powdered psillium-seed, and lime; mix the whole with the white of an egg and horse-radish-juice. Rub the hands with the mixture and let them dry; then rub them again, and you will be able to handle fire.

"2. Dissolve quicklime in bean-water, then mix in Messina earth, to which add a little mallows and bird-lime; rub yourself with it and let it dry.

"3. Rub your hands with strong vinegar in which you have dissolved vitriol, and add plantain-juice."

It was probably by the aid of similar recipes that the priestesses of Diana Parasya, in Cappadocia, according to Strabo, were able to walk barefooted over burning coals; and the Hirpi, according to Pliny, procured exemption from military service by renewing the same miracle annually in the Temple of Apollo, on Mount Soracte. In our own time the Arabian sect of the Aissaouas perform feats quite as astonishing as those we have mentioned. The subject might afford entertaining studies to those who are interested in finding natural ways of accounting for facts which have been regarded as prodigies.—*Revue Scientifique.*

ELECTROMANIA.

BY W. MATTIEU WILLIAMS.

A HISTORY of electricity, in order to be complete, must include two distinct and very different subjects: the history of electrical science, and a history of electrical exaggerations and delusions. The progress of the first has been followed by a crop of the second from the time when Kleist, Muschenbroek, and Cuneus endeavored to bottle the supposed fluid, and in the course of these attempts stumbled upon the "Leyden-jar."

Dr. Lieberkuhn, of Berlin, describes the startling results which he

obtained, or imagined, "when a nail or a piece of brass wire is put into a small apothecary's phial and electrified." He says that "if, while it is electrifying, I put my finger or a piece of gold which I hold in my hand to the nail, I receive a shock which stuns my arms and shoulders." At about the same date (the middle of the last century), Muschenbroek stated, in a letter to Réaumur, that, on taking a shock from a thin glass bowl, "he felt himself struck in his arms, shoulders, and breast, so that he lost his breath, and was two days before he recovered from the effects of the blow and the terror"; and that he "would not take a second shock for the kingdom of France." From the description of the apparatus, it is evident that this dreadful shock was no stronger than many of us have taken scores of times for fun, and have given to our school-fellows when we became the proud possessors of our first electrical machine.

Conjurers, mountebanks, itinerant quacks, and other adventurers operated throughout Europe, and were found at every country fair and *fête* displaying the wonders of the invisible agent by giving shocks and professing to cure all imaginable ailments. Then came the discoveries of Galvani and Volta, followed by the demonstrations of Galvani's nephew Aldini, whereby dead animals were made to display the movements of life, not only by the electricity of the voltaic pile, but, as Aldini especially showed, by a transfer of the mysterious agency from one animal to another. According to his experiments (that seem to be forgotten by modern electricians), the galvanometer of the period, a prepared frog, could be made to kick by connecting its nerve and muscle with muscle and nerve of a recently killed ox, with or without metallic intervention.

Thus arose the dogma which still survives in the advertisements of electrical quacks, that "electricity is life," and the possibility of reviving the dead was believed by many. Executed criminals were in active demand; their bodies were expeditiously transferred from the gallows or scaffold to the operating-table, and their dead limbs were made to struggle and plunge, their eyeballs to roll, and their features to perpetrate the most horrible contortions by connecting nerves with one pole, and muscles with the opposite pole of a battery.

The heart was made to beat, and many men of eminence supposed that if this could be combined with artificial respiration, and kept up for a while, the victim of the hangman might be restored, provided the neck was not broken. Curious tales were loudly whispered concerning gentle hangings and strange doings at Dr. Brookes's, in Leicester Square, and at the Hunterian Museum, in Windmill Street, now flourishing as "The Café de l'Étoile." When a child, I lived about midway between these celebrated schools of practical anatomy, and well remember the tales of horror that were recounted concerning them. When Bishop and Williams (no relation to the writer) were hanged for burking, i. e., murdering people in order to provide "sub-

jects" for dissection, their bodies were sent to Windmill Street, and the popular notion was that, being old and faithful servants of the doctors, they were galvanized to life, and again set up in their old business.

It is amusing to read some of the treatises on medical galvanism that were published at about this period, and contrast their positive statements of cures effected and results anticipated with the position now attained by electricity as a curative agent. Then came the brilliant discoveries of Faraday, Ampère, etc., demonstrating the relations between electricity and magnetism, and immediately following them a multitude of patents for electro-motors, and wild dreams of superseding steam-engines by magneto-electric machinery.

The following, which I copy from "The Penny Mechanic," of June 10, 1837, is curious, and very instructive to those who think of investing in any of the electric-power companies of to-day: "Mr. Thomas Davenport, a Vermont blacksmith, has discovered a mode of applying magnetic and electro-magnetic power, which we have good ground for believing will be of immense importance to the world." This announcement is followed by reference to Professor Silliman's "American Journal of Science and the Arts," for April, 1837, and extracts from American papers, of which the following is a specimen: "1. We saw a small cylindrical battery, about nine inches in length, three or four in diameter, produce a magnetic power of about three hundred pounds, and which, therefore, we could not move with our utmost strength. 2. We saw a small wheel, five and a half inches in diameter, performing more than six hundred revolutions in a minute, and lift a weight of twenty-four pounds one foot per minute, from the power of a battery of still smaller dimensions. 3. We saw a model of a locomotive-engine traveling on a circular railroad with immense velocity, and rapidly ascending an inclined plane of far greater elevation than any hitherto ascended by steam-power. And these and various other experiments which we saw convinced us of the truth of the opinion expressed by Professors Silliman, Renwick, and others, that the power of machinery may be increased from this source beyond any assignable limit. It is computed by these learned men that a circular galvanic battery about three feet in diameter, with magnets of a proportionable surface, would produce at least a hundred horse-power; and therefore that two such batteries would be sufficient to propel ships of the largest class across the Atlantic. The only materials required to generate and continue this power for such a voyage would be a few thin sheets of copper and zinc, and a few gallons of mineral water."

The Faure Accumulator is but a very weak affair compared with this, Sir William Thomson notwithstanding. To render the date of the above fully appreciable, I may note that three months later the magazine from which it is quoted was illustrated with a picture of the

London and Birmingham Railway Station, displaying a first-class passenger with a box-seat on the roof of the carriage, and followed by an account of the trip to Boxmoor, the first installment of the London and Northwestern Railway. It tells us that, "the time of starting having arrived, the doors of the carriages are closed, and, by the assistance of the conductors, the train is moved on a short distance toward the first bridge, where it is met by an engine, which conducts it up the inclined plane as far as Chalk Farm. Between the canal and this spot stands the station-house for the engines ; here, also, are fixed the engines which are to be employed in drawing the carriages up the inclined plane from Euston Square, by a rope upward of a mile in length, the cost of which was upward of £400." After describing the next change of engines, in the same matter-of-course way as the changing of stage-coach horses, the narrative proceeds to say that "entering the tunnel from broad daylight to perfect darkness has an exceedingly novel effect."

I make these parallel quotations for the benefit of those who imagine that electricity is making such vastly greater strides than other sources of power. I well remember making this journey to Boxmoor, and four or five years later traveling on a circular electro-magnetic railway. Comparing that electric railway with those now exhibiting, and comparing the Boxmoor trip with the present work of the London and Northwestern Railway, I have no hesitation in affirming that the rate of progress in electro-locomotion during the last forty years has been far smaller than that of steam.

The leading fallacy which is urging the electro-maniacs of the present time to their ruinous investments is the idea that electro-motors are novelties, and that electric-lighting is in its infancy ; while gas-lighting is regarded as an old or mature middle-aged business, and therefore we are to expect a marvelous growth of the infant and no further progress of the adult. These excited speculators do not appear to be aware of the fact that electric-lighting is older than gas-lighting ; that Sir Humphry Davy exhibited the electric light in Albemarle Street, while London was still dimly lighted by oil-lamps, and long before gas-lighting was attempted anywhere. The lamp used by Sir Humphry Davy at the Royal Institution, at the beginning of the present century, was an arrangement of two carbon pencils, between which was formed the "electric arc" by the intensely vivid incandescence and combustion of the particles of carbon passing between the solid carbon electrodes. The light exhibited by Davy was incomparably more brilliant than anything that has been lately shown either in London, or Paris, or at Sydenham. His arc was *four inches in length*, the carbon pencils were four inches apart, and a broad, dazzling arch of light bridged the whole space between. The modern arc-lights are but pygmies, mere specs, compared with this, a leap of one eighth or one quarter inch constituting their maximum achievement.

Comparing the actual progress of gas and electric lighting, the gas has achieved by far the greater strides; and this is the case even when we compare very recent progress. The improvements connected with gas-making have been steadily progressive; scarcely a year has passed from the date of Murdoch's efforts to the present time, without some or many decided steps having been made. The progress of electric-lighting has been a series of spasmodic leaps, backward as well as forward. As an example of stepping backward, I may refer to what the newspapers have described as the "discoveries" of Mr. Edison, or the use of an incandescent wire, or stick, or sheet of platinum, or platino-iridium; or a thread of carbon, of which the "Swan" and other modern lights are rival modifications.

As far back as 1846 I was engaged in making apparatus and experiments for the purpose of turning to practical account "King's patent electric light," the actual inventor of which was a young American, named Starr, who died in 1847, when about twenty-five years of age, a victim of overwork and disappointment in his efforts to perfect this invention and a magneto-electric machine, intended to supply the power in accordance with some of the "latest improvements" of 1881 and 1882. I had a share in this venture, and was very enthusiastic until after I had become practically acquainted with the subject. We had no difficulty in obtaining a splendid and perfectly steady light, better than any that are shown at the Crystal Palace. We used platinum, and alloys of platinum and iridium, abandoned them as Edison did more than thirty years later, and then tried a multitude of forms of carbon, including that which constitutes the last "discovery" of Mr. Edison, viz., burned cane. Starr tried this on theoretical grounds, because cane being coated with silica, he predicted that by charring it we should obtain a more compact stick or thread, as the fusion of the silica would hold the carbon-particles together. He finally abandoned this and all the rest in favor of the hard deposit of carbon which lines the inside of gas-retorts, some specimens of which we found to be so hard that we required a lapidary's wheel to cut them into the thin sticks.

Our final wick was a piece of this of square section, and about one eighth of an inch across each way. It was mounted between two forceps—one holding each end, and thus leaving a clear half-inch between. The forceps were soldered to platinum wires, one of which passed upward through the top of the barometer-tube, expanded into a lamp-glass at its upper part. This wire was sealed to the glass as it passed through. The lower wire passed down the middle of the tube. The tube was filled with mercury and inverted over a cup of mercury. Being thirty inches long up to the bottom of the expanded portion, or lamp-globe, the mercury fell below this and left a Torricellian vacuum there. One pole of the battery, or dynamo-machine, was connected with the mercury in the cup, and the other with the upper wire. The

stick of carbon glowed brilliantly, and with perfect steadiness. I subsequently exhibited this apparatus in the Town-Hall of Birmingham, and many times at the Midland Institute. The only scientific difficulty connected with this arrangement was that due to a slight volatilization of the carbon, and its deposition as a brown film upon the lamp-glass; but this difficulty is not insuperable.—*Knowledge.*

ANTHROPOID MYTHOLOGY.

By Dr. B. PLACZEK.

SHAKESPEARE in one place calls sleep the "ape of death," and thereby gives living expression to an idea which men have at all times entertained of their "nearest relative." As sleep to death, so according to the vulgar view is the ape related to man. Sleep is not quite death, and is no longer conscious life, but is something between the two; and man learns to regard it as a counterfeit of death. We may say, in general, that wherever men have come into close contact with monkeys they have acquired the same impression of them, that they are a caricature of man, and the idea that they are a not-yet man or a no-longer man, a human likeness of a more primitive design or one that has suffered deformity. All of the more ancient conceptions of the relations between men and apes thus waver between variation and degeneration. The shape which the idea of a community of the two principal families of primates has taken, among the partisans of creation as well as of transformism, can be followed, from divination to empiricism, from superstition to scientific description, and it is not strange that among all the theories of the doctrine of development the so-called "monkey theory" has spread most rapidly and widely. Besides the myths and legends in which the face of an ape now and then appears—fables, the fundamental idea of which carried out by skillful and careful minds assumes a scientific value—we meet, among the more ancient peoples who made the anthropoid apes the subjects of scientific disputes or invested them with religious or ritual interest, far more important expressions of a supposed relationship of those creatures with man.

The most ancient literature of the Hebrews is eminently a rich and inexhaustible treasury of observations of nature and inquiries into it. We shall first concern ourselves with these, and then draw from Arabian, Egyptian, Indian, ancient Mexican, and other stores, their ape-lore so far as it is of scientific interest and approaches the present conceptions of the nature of apes. Of the joint triennial voyages of the Israelite and Phœnician fleets to Africa, 1 Kings x, 22, says: "For the king had at sea a navy of Tarshish with the navy of Hiram;

once in three years came the navy of Tarshish, bringing gold and silver, and ivory, and apes, and peacocks." This is repeated in 2 Chronicles ix, 21. The joint expeditions to Ophir referred to in 1 Kings ix, 27, 28, x and xi, and in 2 Chronicles ix, 10, were probably of the same kind. The name of Tarshish (Tartessus in Spain), the most important trading-point of the Phœnicians, had probably come into application to designate all large merchant-vessels designed for long sea-voyages, in whatever direction they might be accustomed to sail. The Hebrew names for apes, *kofim* (singular *kof*), and peacocks, *tukijim*, undoubtedly point to an Indian derivation. For *kof*, ape, is in Sanskrit *kafi*, "the nimble," and *tukij* corresponds with the Malabar *tôgai*. The apes which the sailors of those times brought back from their distant journeys were probably Asiatic, even if the possibility is not excluded that the Israelite-Phœnician ships occasionally touched the African coasts and brought monkeys thence. That different kinds of monkeys were kept by the ancient Hebrews as pets, and were also trained for employment in household tasks, appears in numerous places in the post-Biblical literature. Four kinds of monkeys were particularly mentioned: *kof*, the ape in general, where it alone is named; when it appears at the same time with others it perhaps refers to the Indian *Hanuman* (*Semnopithecus entellus*); *kipud* or *kipuph* (regarded by some commentators as an abbreviation of cercopithecus), a tailed ape or baboon; *Adne-hasadeh*, or *Abne-hasadeh*, or *Adam-hasadeh* (according to Bochart), or *Bar-nash-ditur*, corresponding with the orang-outang or the anthropoid apes; and *Delphik*. Everywhere is a relationship of the ape with man suggested, and in the ritual casuistics the ape is regarded as a kind of man, and so considered in view of the religious law. At the sight of an ape or a monkey, the benediction was uttered, "Praised be he who changes his creatures!"—an allusion to the belief which was found among many ancient people, especially among the Arabs, that the ape was a degenerated form of man, or that the latter took on the outward appearance of the ape in consequence of moral degeneration (Talmud, B. Berachoth, 58 b.). But since the ape to which the benediction applies is placed in the same category with a negro, albino, or dwarf, the idea appears to underlie it that the variation is an inborn one. The former acceptation is supported in Berachoth 57 b., "To see an ape or a monkey in a dream is a bad sign"; and in Bereschit Rabba C., 23, "In the time of Enoch men were changed into apes." Rabbi Jose taught that the corpse of an Adne-hasadeh was unclean in the tent the same as that of a man, while the laws in the case of the bodies of beasts were quite different. Immediately afterward the same Rabbi Jose expresses the opinion that the ape (*kof*) must be regarded as an undomesticable or hardly domesticable animal. According to him, the Adne-hasadeh stands much nearer to man than the common ape or than any other tailed species of ape. It appears from Joma 29 b and Menachot 100 b, that the ape

was employed in household tasks: "If the show-bread is not arranged according to the directions upon the holy tables in the temple at Jerusalem, it is just as though an ape had done it." According to Idajim, 1, 5, the ape could be employed in connection with certain religious ablutions; but the Rabbi Jose, named above, denies him this property. Baba Kama speaks of apes being trained to keep the house clear of vermin; and it is well known that they will eat the smaller animals, such as young birds, mice, bugs, and caterpillars, as dainties.

Of the tricks of apes, Baba Kama tells of one of the animals that stole dye-stuff and colored wool with it. Nedarim mentions one that ran away and was found in a cave along with the treasures that it had collected there. Duvaucel, Brehm, and others, say that Indian apes steal and conceal gold, precious stones, and other bright things.

The palatableness of the milk and blood of bipeds is spoken of by several Talmudic authors, and the question is suggested why, if only men are meant, the term biped should be exceptionally used. The glossater, A. ben David, adds the remark, "such as man"; while Jizchaki says, "Only man is meant here." The erect anthropoids may, however, also have been in the thought of the writers. In exposition of Leviticus xi, 27, "And whatsoever goeth upon his paws, among all manner of beasts that go on all four," it is remarked in the Sifra, 51, "By these are meant the ape (*kof*), the *Kipud*, and *Adne-hasadeh*." A. ben David says in this connection: "While the ape resembles man in form, and has fingers on his hands and toes on his feet like men, he is nevertheless ranked among the other animals as unclean." In Jebamot, it is said that a deformity of a man's foot by which the toes are bent under the sole so that he has to walk on the back of his foot, renders him unfit for the performance of certain ceremonies. In Moëd Katon is an allusion to a funeral orator, named Bar Kipuph (son of an ape or ape-man), who had a deformity of this kind, and probably received his nickname in consequence of it. Robert Hartmann says that the chimpanzee and orang-outang go on all-fours, bending their fingers into the hollow of their hands, and setting the calloused back of their hands on the ground; and this explains why the gait of crippled persons was called ape-like, and why the orator was called Bar Kipuph. Sometimes we meet the expression, "like the act of an ape," a bare imitation.

The fables of the *Abne*, *Adne*, or *Adone-hasadeh*, have assumed very strange forms. While the Talmudic and Midraist representations of this being distinctly point to an authropoid ape, the name of which may appear in Job v, 23—"For thou shalt be in league with the stones of the field; and the beasts of the field shall be at peace with thee"—where the word in the original translated stones is believed by some to refer more properly to this animal—the interpreters and glossaters, following the fashion of the grotesque fables of great apes, have made a formidable monster of it. Kilajim describes it as the

Bar-nash-ditur (man of the mountain), which can live only through the umbilical cord, and dies if it is broken. Maimonides says the Adone-hasadeh are animals resembling men. Travelers wrote of the animal that it talked much and intelligently, even with a human articulation. In Arabic it is called *alnanas*, which Buxdorf translated νάνος, nanos, dwarf (in Talmudic *nanos* means shut). Clearness is lent to the supposition that these accounts referred to apes by the fact that E. Tison, in 1698, methodically dissected a female chimpanzee from Angola in Africa, and called it a pygmy, comparing it with the accounts of the ancients respecting alleged dwarf races in Ethiopia, which races, however, modern ethnologists recognize in several real living tribes of diminutive size. Simson asserts in a note to Kilajim, 8, 5, that he had heard that the Abne-hasadeh was the animal *Jodua*, through a bone of which, according to Talmud Synhedrin 65, a, b, the wizards mentioned in Leviticus xix, 31, and xx, 6, and in Deuteronomy xviii, 11, placing them in their mouths, were able to prophesy; "and how a great cord rises out of a root in the ground on which the Jodua grows like a squash or melon; his face, body, and limbs are like those of a man, but the navel is joined to the cord that rises out of the earth-root. No being dare venture within reach of the cord, for fear of being destroyed, and the animal devastates everything within the circle which the cord describes. No man can approach it with safety; and, if any one wishes to overcome it, he must endeavor to lay hold of the cord and break it, or shoot through it from a distance with an arrow, when the animal dies." We apparently have to deal here with a conglomeration of fables of different times and places. There are, first, exaggerations in the sketches of the great anthropoid apes, from Hanno in his *periplus* to the fanciful Du Chaillu, not to speak of the fabulous impossible accounts that appear in Pliny, Ælian, and other ancient writers. The Adne-hasadeh, or Jodua, except as to the navel-cord, corresponds well with the authentic accounts of the gorilla as we find them in the works of Brehm, Dr. Franquet, R. Burton, Lenz, Gürsfeld, and Koppenfels. By means of the navel-cord we may recognize in the Adne-hasadeh a plant-animal, a kind of *Boranetz*, of the fable of which Lewysohn, in his "Biology," introduces the following account: "In this steppe or desert (Lesser and Great Tartary) is found the Boranetz, or Bornitch, as some call it, a fruit as large as a melon, having the form of a sheep (whence it gets the name of Boran, Russian for *sheep*), with a head, feet, and snout, and, what is remarkable, this fruit has on the outside a skin covered with white, bright, and very finely tinted hair, firm as silk. These skins are valued very highly by the Tartars and Russians. This Boranetz grows on a bush three feet high, which implants itself in the navel of the sheep. The fruit turns, like a summer flower, as if it would incline itself toward the plants near it. They tell of it, that if the grass and plants around it dry up, the fruit perishes for want of food and support; and the same

happens if the surrounding vegetation is cut and taken away green. They say also that wolves are very fond of the Boranetz, and that it has within meat, blood, and bones." The Adne-hasadeh has, however, none of the lamb-like character of the Boranetz, but, on the contrary, a spirit averse to restraint.

I believe a slight etymological rectification will give us a clew to the conception out of which this fable has grown. For *tabur*, navel, substitute *tabaat*, fundament, and from the cord connecting the navel with a root in the ground we are led to the tail, by which the animal hangs itself to a limb or a projecting root. The accounts of the ferocity of the Adne-hasadeh need not be rejected as silly and monstrous when we recollect how mischievous and destructive some apes are, as, for instance, the *Cynocephalus sphynx*, which may have stood for the original Adne-hasadeh, and which carries desolation into fields and gardens.

An important part is also assigned to apes in legends and parables. "When Noah was about to lay out his vineyard, Satan came up and asked him, 'Would you like to have me with you at the planting and the wine-making?' 'I am digging,' said Noah, evasively. What did Satan do? He brought up a lamb, a lion, a hog, and an ape, and killed them all in the vineyard till it was soaked with their blood. Thus it happens that man is soft and mild as a lamb after the first draughts; that he feels as brave and strong as a lion when he has drunken as much as agrees with him; then, when he has drunk more than enough, he becomes like a hog, disagreeable and boisterous; and, finally, when quite drunk, staggers and tumbles around, and makes faces, like a monkey." Perhaps the expression "to get as tipsy as a monkey" is derived from this. Synhedrin relates of the time of the confusion of tongues: "At the building of the tower of Babel men divided into three parties. One party said, 'We will go up to heaven and settle there'; the second party said, 'We will pray to our gods up there'; and the third party said, 'We will go up and make war.' The last were changed into apes and devils."

Seven vanities, says the "Kohelet," correspond with the seven phases of the life of man. When he comes into the world, everything kisses and embraces him; from two to three years old, he is like a pig, dirty, rooting everywhere, putting everything into his mouth; at ten years old he is jumping and capering about like a goat; at twenty, he is a horse, vain, enthusiastic, eager, looking around for a wife; when he takes a wife, he becomes an ass, bears burdens, and if he has children he is harassed like a dog to support them; and, when old, he becomes capricious and irritable, like an ape." A later writer, Salomo Ibn Verga, toward the end of the fifteenth century, describes the course of all things and beings as follows: "The coral forms the transition between the mineral and the vegetable kingdom, the sponge between the vegetable and the animal, and the ape is the intermediate

member between the animal and the man." Jalkut Reubeni remarks, "The ape veils itself before man as man does in the presence of the Shekinah." We recognize in this view the law brought into vogue by Leibnitz, and extended by Bonnet, of the continuous graded ascent of created beings. Finally, it is proper to state here that, according to the agadistic view, the primitive man as well as the ape, for the most part, lived only on vegetable food. "Flesh-eating was forbidden to Adam as well as to all his posterity till the time of Noah," say Lekachtob, Synhedrin, Jalkut Chadash, and Sefer Chassidim.

While the references to apes in the ancient writings of the Hebrews are generally of a matter-of-fact character, the stories and delineations by the ancient Arabians have, as a rule, a romantic stamp. The ape-men Nesnâs, which Maimonides believes to mean the Adne-hasadeh, play a conspicuous part in the Arabian travelers' stories, their romances, and their theology. I may state here that the ape is called in modern Arabic Nesnâs or Nasnas. A Mohammedan tradition runs: Ibn Abbas said: "Men (Nâs) have perished and the Nesnâs are left." He was asked, "What are Nesnâs?" and he replied, "Creatures which are like men and are still not men." Al-Gauharî defines the Nesnâs as "creatures that hop on one leg." The Nesnâs are very fully described by Al-Kazrwini as animals of a half-human figure which serve the people as food. They have half a body, half a head, a hand, and a leg, as if they were men split in two. This idea is, I believe, only the too literal and hyperbolical carrying out of the description of an ape as half a man. Wüstenfeld translates Nesnâs by "one-legged creature," and deduces from citations which he makes, that God changed men into Nesnâs as a punishment. The Koran, Surah ii, says: "You know what happened to those among you who profaned the Sabbath. We said to them, be apes and be excluded from human society, in order that they might be an example for the present and the future, and a warning to the pious." The Nesnâs were said to be Shemites, and descended from Shem's son Hasim; to speak Arabic, and to have Arabic personal names Ibn Ajjas, in his cosmography, describes the Nesnâs as creatures with one eye, one ear, and one leg. Maçudi gives a similar description and adds, that they rise out of the sea. The Nesnâs killed such men as they could catch.

According to another view, the Nesnâs were identical with Gog and Magog. Arabian historians speak of an invasion by a pygmy people called Nesnâs into Southern Arabia—a tradition which is referred by Fresnel to the irruption of the Roman legions. The question is raised in the casuistics of Mohammedan ritual, whether it is right to eat the flesh of the Nesnâs. As a rule such food is absolutely forbidden. Al Tabbarîi permits it, because aquatic animals are generally not forbidden. Wahrmund defines the Nesnâs as a "large ape, an orang-outang, a chimpanzee; a one-armed and one-legged satyr that hops fast." Muhîs-al-Muhîs of Albustâni says: "It is related in tradition

that a branch of the tribe of Ad rebelled against its prophets, and God changed them into Nesnâs, that is, into creatures with one hand and one leg, which hop like the birds and eat grass like the cattle. They say that this race has died out, and that such creatures of the kind as are found now are of a different creation (are not changed men). Common people call apes Nesnâs."

The ancient Egyptians did not represent the ape as a caricature of man, but idealized it and paid it religious honors, as they did to many other animals. A cynocephalus was kept and worshiped in the temple at Hermopolis, while a cercopithecus was honored at Thebes. Mummies of apes have been found in both of these cities. The ape also has its place in the hieroglyphics as the representative of the sound "en," and is called *ein* in Coptic. The god Anubis, who, at the judgment of the dead in Amenti (or the land of death), put the heart of the deceased in the balance of justice in order to report the result to Thoth, is figured with the head of a cynocephalus, or dog-faced baboon. Thoth himself generally appears associated with the attribute of the cynocephalus, the emblem of the dog-star. The temple of Queen Hatasu, at Der-el-bahri, is adorned with inscriptions relating to a grand expedition into the balsam-bearing land of Punt, the Egyptian Ophir, in which the offerings sent by the king of that country are described : "The transports were loaded to the full with the wonderful products of the land of Punt, and the various building-woods of the godly land, with heaps of balsams of incense, with green incense-trees, with ebony, with ivory, adorned with gold from the land of Amu, with liquorice-wood, chefit-wood, with frankincense, holy balsams, and eye-paints, with cynocephaluses and baboons and greyhounds, and with leopard-skins. Never was the like brought to any king of Egypt since the world has stood." According to Brugsch, the incense-trees stood on the decks of the vessels, and the apes, let loose, gamboled in the rigging, to the great delight of the sailors.

In the Indian Râmayana, where the animals are praised as allies of Rama, apes are depicted in groups, under the direction of a king who obeys the nods of Rama. They are not, however, introduced as idealized apes, changed men or incarnate demons, but as veritable apes with all their less pleasant peculiarities realistically portrayed. A favorite figure of the poem is Hanuman, the fool of the serious drama, around whom a fabulous atmosphere has already gathered. In him may be recognized the Hulman of the Hindoos, the Mandi of the Malabars, the sacred ape, *Semnopithecus entellus*. He is an Atlas, who bears mountains on his shoulders. A child of the wind and the air, he affords the most agreeable symbolism of the simian character. Like a rash child, he tried to go up to the sun, and still carries a remembrancer of his mishap in the deformity of his lower jaw, which is longer than the upper one. With his foolhardy, comic ways, he cheered and comforted Rama's beloved wife Sita, and helped deliver her from the

terrible Lanka, the city of the demon-king Râvana. In gratitude for this, Rama crowned him and embraced him in the sight of both hosts, of men and of gods.

In no land in the world has honor to apes struck as deep root as in India. Formerly temples were consecrated to them, and now, as Tavernier relates, asylums, special gardens, and hospitals are erected for them; and the Hulman is particularly regarded as sacred. Captain Johnson states that the natives of Baka leave a tithe of the harvest on the field for the Bhunder (*Macacus Rhesus*); and the penalty of killing this ape was death. The mild, human-like face of the orang-outang when quiet, and his deliberate, gentle, docile manner, contrasting with the nervous, convulsive restlessness of other monkeys, were well adapted to win for him the favor and reverence of the Indians; and this was apparently not affected by the knowledge of the ferocious appearance and manner he exhibits when enraged. The Javanese, remarking upon these features, say, "Monkeys could speak if they would, but they do not, because they are afraid that if they did they would be put to work." Indian princely families boast of their descent from apes, and bear the title of "tailed Rana." In the Indian metempsychosis the souls of the pious after death pass into the Hulman.

The apes of the New World received a similar treatment from its aborigines to that which was given to their relatives in the Old World. A remarkable correspondence is observable between the Aztec hieroglyphics for the days and the animal symbols which the Eastern Asiatics apply to the designation of the course of their year. The symbols in the Mongolian calendar are derived from animals, and among them four of the twelve coincide precisely with those of the Aztec calendar, and three are as nearly the same as the difference in the genera of the two hemispheres permits them to be. This will appear more plainly as an enumeration of the animal signs used by the Eastern Asiatics in describing their years. Among the Mongols, Mantchoo Tartars, Japanese, and Thibetans, they are the mouse, the ox, the leopard (or tiger), the hare, the crocodile (or dragon), the serpent, the horse, the sheep (or goat), the ape, the hen, the dog, and the hog. Among the Mexican names for the days we also find the hare, the serpent, the ape, and the dog; and instead of the leopard, crocodile, and hen, which were unknown in Mexico at the time of the conquest, the panther, lizard, and eagle. Thus, the Mexicans made the ape a symbol in the division of time and in chronological reckoning. Aztec traditions make mention, like those of the Hindoos, Thibetans, Persians, and Greeks, of four or five cataclysms, of cycles, after the fulfillment of each of which the world was destroyed, to be recreated anew. The belief in the recurrence at appointed times of these revolutions of nature through the operation of one or another of the elements was peculiar to many lands of the Eastern hemisphere, and has often been advanced as an argument in favor of the doctrine of a common origin.

The third age of the Mexicans, that of air, in which the Mayas conquered the giants of the former age, lasted 4,010 years, and ended in a hurricane by which all men except one pair were turned into apes. In the four ages of the Mexicans, which were called the ages of earth, fire, air, and water, we have to deal with a backward development, from giants to men, then to apes. This shows a curious agreement with the story of the Talmud, already referred to, that a part of the race at the confusion of tongues were turned into apes. It also curiously corresponds with the ancient Indian myth that made the ape a child of the wind and the air.

While the folk-lore on one side degrades the ape to a degenerate species of man, it on another side in compensation, as in Indian and among many negro tribes, derives the pedigree of distinguished families from apes, and consigns the souls of the honorable and pious to their bodily integuments. According to Brehm, the hair-tuft of the baboon serves the negroes of West Africa as the model for their coiffures. That lowly race also tries to exalt its similarity with the ape which the satirists of every zone make striking enough, and a humorous writer was not so far wrong when he described an ugly man as "a baboon, with hairs projecting from around his eyes." Not only bodily deformities and imperfections have been ascribed to apes, but moral transgressions also have been regarded and spoken of in the same view.

That the faculty of articulate speech is dependent on an upright position is suggested in the Hebrew book "Sohar Chadash," which says: "The animals can not look straight up to heaven, and therefore can not speak; and we learn of King Nebuchadnezzar that, when he was reduced to the condition of an animal, he could not help himself until he was able to rise and look up. Therefore he said to Daniel (Daniel iv, 34), 'I raised my eyes to heaven, and then my understanding returned to me.' If the animals, walking erect, could look up to the sky, they would be able to speak."

THE POISONS OF THE MANUFACTORY.

By HECTOR GEORGE.

THE cases of contamination of the air by means of insalubrious industrial operations may be divided into two groups: 1. Emanations (dusts or vapors) that act as poisons, and which, carried by the blood to all parts of the body, produce general and various disorders. 2. Dusts, of a simply irritating character, which act locally on the lungs, and produce in them disorders the intensity of which generally depends on the hardness of the particles.

We will begin with the poisonous dusts, taking first one of the most murderous classes—those of lead. Accidents due to lead are liable to occur among many classes of operatives who work with this substance either in a metallic state or in combination. Painters, miners, plumbers, type-founders, compositors, and glass-makers are peculiarly exposed to them.

The most obvious precaution to be taken against the admission of poisonous dusts with respired air is to arrest their passage by means of a protective veil or mask. An insurmountable obstacle has prevented the use of such a precaution. The workmen will not wear the screens, although effective and convenient ones enough have been made. Workers in white-lead ought also to wear special clothing for their work; but all that it has been possible to get them to do is to cover their ordinary clothing with overalls. This does not give sufficient security against the transportation of lead-dust by the clothes. Other important measures are those which have regard to cleanliness; here, again, we are opposed by an obstinate resistance. In a shop at Washington, near Newcastle, England, where the oxychloride of lead is prepared, the workmen quit because of an effort to introduce baths among them. They would not be shut up in a bath-room, although they would bathe very readily in the open air or in swimming-ponds.

A very essential precaution that workmen should always take is never to deposit or eat their food in the shop, or allow it to be in any way exposed to mixture with poisonous dusts.

Attention has been directed toward finding an antidote to lead-poisoning. M. Meisens, in 1843, recommended iodide of potassium, and it has been used with excellent effect; it cured declared diseases, as, for instance, paralysis; and permitted the continuance of work in lead without danger from colic. The Academy of Sciences awarded a prize for the discovery. Milk was recommended as a preventive of lead-poisoning by M. Didier-Jean, director of the glass-factory at St. Louis, near Sarreguemines, in 1867; but the workmen were not disposed to use it, and found a way to bring alcoholic liquors to the shop instead of milk.

General hygienic measures against this source of danger include the suppression of lead-dusts, that is the production of as little as possible of them, and the removal of them as soon as they are produced. Moistening, grinding, and mixing under water, closed apparatus for pulverizing, natural and artificial ventilation, substitution of machines for the hand, and mechanical packing—such are the improvements adopted by the factories at Brussels and Lille, with great advantage to the health of the workmen. Of two white-lead factories in Paris a few years ago, one was very unhealthy, furnishing from two hundred and fifty to two hundred and eighty patients a year to the hospitals; while the other, with the same number of men employed, was only slightly unhealthy, and furnished only two or three patients a year, or

a hundred times less. The difference depended on one condition only. The former factory made white-lead in powder or in cakes; the other prepared and sold it exclusively ground in oil. In the former process much dust, in the latter none, was disengaged.

Another step in progress may be gained, perhaps, by substituting inoffensive substances for the compounds of lead employed in industry. White-lead has already a rival in zinc-white, but it is objected to that substance that it has an inferior coloring power. To meet this objection, Mr. Griffith, of England, has prepared a white coloring substance based on sulphuret of zinc, which combines the coloring power of white-lead with the inoffensive qualities of the salts of zinc.

A pharmacist of Brest, M. Constantin, has received a prize from the French Academy of Sciences for the discovery of substitutes for the use of oxide of lead in the glazing of pottery: glazes based on lime for the uncolored, on oxide of manganese for colored, glazings.

A number of inoffensive colors deserve mention as substitutes for poisonous colors. Such substances as eosine, fluorescine, and other products derived from aniline, have been fortunately introduced in later years for painting children's toys.

Nothing need be said of copper. It is as inoffensive as lead is dangerous; and it appears, according to the researches of Dr. Burq, to confer upon workmen who handle it an almost absolute immunity against cholera.

Mercury is as dangerous as lead. It provokes salivation, destruction and loss of the teeth, tremblings, paralysis, and death. The workmen exposed to injury from it are miners employed in its extraction, gilders, looking-glass makers, and hatters. The personal hygiene is the same as for lead; but in securing its application we are still opposed by the carelessness and foolhardiness of the workmen.

The principal means relied upon for preservation against accidents from mercury are the employment of ammoniacal sprays in the shops, and of iodide of potassium, as for lead. Both remedies were recommended by M. Meisens after a long series of experiments, and have been used with excellent effect. The division of the labor in its most insalubrious phases and an energetic ventilation are excellent measures. Operations in mercury have been, moreover, much alleviated by the introduction of new processes. Gilding with mercury has been replaced by galvanoplasty; silvering of glass with mercury by a plating process which is performed at half the cost, and is without danger to health. Mercury is used by hatters in a secret process for impregnating the fur of the hare and rabbit, to make it felt, with a mixture of mercury, nitric acid, and water. Efforts have been made to find a substitute for quicksilver, and Dr. Hillairet proposed in 1872 to use molasses, but the experiment was not satisfactory.

Phosphorus is but little used among us except in the manufacture of matches. The troubles which it occasions are cough, headaches,

and disorders of the stomach. In the gravest cases, the inhaling of the vapors causes a more or less complete destruction of the bones of the jaws, in which they produce necrosis, especially in persons with decayed teeth. Such disorders have, however, become more rare. Besides finding a way to neutralize phosphoric vapors by essence of turpentine placed in a bottle, to be hung from the workman's neck, the vapors themselves have been suppressed by the adoption of processes in which all the dangerous parts of the operations are performed by machinery.

The General Match Company of France, which enjoys the monopoly of the manufacture in that country, has gradually introduced machinery, within the last ten years, by which the mixture of the phosphorus paste, the dipping of the matches, and the packing, are all done without exposing any one to the inhalation of the vapors.

Sulphide of carbon, which possesses the property of softening and inflating India-rubber, is much used in the manufacture of India-rubber foot-balls and balloons of various kinds. It occasions pains in the head and limbs; loss of appetite; paralysis of the sight, the hearing, and the limbs; cachexy, and death. It should not be handled except in closed vessels. M. Deschamps, of Belleville, invented a glass box, having two openings, for the passage of the hands and arms, to which were attached India-rubber sleeves, to be fastened at the wrist, and enable the hand to work within the apparatus without giving any outlet for the vapors; but the workmen laughed at the apparatus, called it a magic-lantern, and would not use it. There remains, then, no other resource than an active ventilation to carry off the poisonous vapors; and for that reason work in sulphide of carbon should be carried on only in large establishments, well ventilated, and should be excluded from small rooms.

Passing by the manufacture of chemicals, which is a special industry, involving many peculiar causes of insalubrity, and which deserves a full treatment by itself, we come to dusts that are simply irritating. They may be divided into two groups: those which are not soluble in the liquids of the body, and consequently accumulate in the lungs, and obstruct them; and those which, being soluble, have only a transient effect, and do not produce irremediable disorders. The first group includes the coal and the siliceous dusts; the second group all the others.

The accumulation of coal-dusts in the pulmonary vesicles produces, in coal-miners, workers in charcoal, and copper-founders, a malady designated by the name of *anthracosis*, which frequently ends in death. The lungs of victims of this disorder resemble a piece of sliced coal. In the personal hygiene against these elements, we mention the use of wadded masks, which has been followed by excellent effects in the mines of Belgium, where it has been possible to get them adopted. In general hygiene, Dr. Manouvriez (of Valenciennes),

some time ago recommended the projection of water, in the form of rain, to bring the dust to the ground. Fecula and talc have been used as inoffensive substitutes, in iron-founding, for charcoal, as the dusting between the mold and the melted metal.

Siliceous dusts are apt to arise especially in the making and re-dressing and re-cutting of millstones. They accumulate in the bronchiæ, which they scratch, and produce one of the most painful of coughs, with decline and loss of strength. Sometimes an eliminatory inflammation supervenes, with expectoration of masses of siliceous dust, particles of steel, and bits of bronchial membrane, and gives a temporary relief. But the disorders return, and the workmen have to leave the shops, to continue in a condition of marasmus an existence which is terminated by a premature death. The victims of this disease, called the St. Roch disease, are hardly ever able to endure more than eight or ten years in their occupation.

The dusts, moreover, which accumulate in the throat produce an incessant thirst, and lead the workmen to habits of intoxication. M. Mercier, of La Ferté-sous-Jouarre, a manufacturer of small mills, who himself works at the stones, has contrived a very thin and inexpensive silken veil, to which he has attached spectacles, for the protection of the eyes. He has used it with great success since 1870, but has not been able to induce more than twenty or twenty-five of his workmen to adopt it. The others laugh at it, and die of the dust against which they will not protect themselves.

Among the siliceous dusts should be included those arising in the manufacture of porcelain. At Charenton, St. Maurice, Montreuil near Paris, and Sarreguemines, the workers in porcelain die very frequently of pulmonary phthisis, hardly reaching more than the average age of forty-four years and a half, and rarely passing fifty years. The protecting veil ought to be used here also.

The dusts of gypsum, on the other hand, appear to be inoffensive, and even hygienic, according to Dr. Burq, who is almost tempted to attribute to them a salutary action in pulmonary phthisis. At any rate, the workmen recognize them as pleasant. They have only the single inconvenience, common to all dusts, of provoking thirst; and that thirst is not always quenched with pure water.

LITTRÉ, DUMAS, PASTEUR, AND TAINE.

THE names which we have placed at the head of this article are those of four of the most illustrious representatives of the intellect of France in the present age. M. Littré, whose recent death the Academy and the world of letters have to deplore, takes rank among

the greatest masters of language; M. Dumas still pursues his valuable researches in chemical science, and he combines with them an eloquence and elegance in literary composition not unworthy of his scientific renown; M. Pasteur has carried to their farthest limit the investigations of physiology, and has rendered incalculable services to mankind by tracing to their sources the germs of life, and of the diseases which affect life; M. Taine must be placed among the best French writers left to us since the extinction of the great historians, critics, and orators of the last generation. By a fortunate accident three of these eminent persons were called upon to take part on two memorable occasions beneath the dome devoted to the public sittings of the French Institute. That building, dedicated to letters, to science, to art, and to criticism, may be regarded as the last refuge and asylum of the genius and culture of France. It has resounded for two centuries to the voices of the great leaders of thought and eloquence of former generations; it still collects within its walls whatever is best and noblest in French society. This institution alone survives the great cataclysm which has swept away thrones, and churches, and orders, and constitutional government. The National Institute, and especially the oldest branch of it, the French Academy, still pursues its calm and dignified course, unshaken by despotism, by sedition, by popular tumults, by the violence of war, or by the scourge of revolution. Even during the siege of Paris we believe that its sittings were scarcely interrupted. Beneath the customary forms of academic compliments, which are in themselves idle ceremonies, it is not difficult to trace in its proceedings the language of earnest thought and warm feeling; and we shall have occasion to show that the great conflict of the age between faith and science, between the intellect and the senses, between spiritualism and materialism, between mind and matter, between the finite and the infinite, was the real subject of the discourses delivered on the occasions to which we now particularly refer.

But there was in this encounter a peculiar contrast. M. Littré, to whose memory the speech of M. Pasteur was devoted, was himself a Comtist; his philosophy was entirely negative; he denied everything which could not be brought within the evidence of the senses. These agnostic opinions were strenuously assailed by the eminent man of science whose duty it was to relate the touching history of his life. M. Taine, who had been elected to the Academy two years before in the place of M. de Loménie, disclaimed all adherence to Comtism, and spoke with very little respect of its founder, but his language was not less skeptical; it was a distant echo of the philosophy of the eighteenth century, which destroyed all beliefs and planted nothing in their place; it was an avowal of the supremacy of matter over mind, which is characteristic of all his own writings. To him M. Dumas replied with great force and point. The great chemist told him that all the researches of the present generation into the secrets of the material

creation indicated the existence of powers infinitely beyond it, and that the utmost advance in scientific knowledge only brought us to the verge of an incalculable horizon. The discourse in answer to M. Pasteur was delivered by M. Renan, but it proved to be a feeble and disjointed effort of French incredulity, without its wit. So that the cause of skepticism and negation was on these occasions upheld by the men of letters, inquirers into the origin of language and the phenomena of history, while the cause of belief in an infinite and supernatural power was defended by the men of science, whose lives have been devoted to the study of the natural world and to demonstration by the experience of the senses. The contrast was striking, and we think our readers may follow it with interest.

But, before we proceed to that part of our subject, we must pause to pay a tribute of respect, unhappily too long delayed, to the memory of the most remarkable of these eminent persons. There are other experimentalists, there are many historians, but M. Littré stands alone as the greatest of lexicographers, and the literary work accomplished by his almost unassisted labor was literally stupendous. We can use no other term. The character of the great "Dictionary of the French Language," to which he devoted thirty years of unremitting toil, is best described by its elaborate title-page. The mere material bulk of the work, which was published in four thick quarto volumes, is astonishing. The manuscript (without the supplement) covered 415,636 pages. The proof-sheets were 2,242. If the "Dictionary" had been set up in a single column of type, it would have extended over 37,325 metres, or about twenty-seven miles. The work was first projected in 1841, when M. Littré had already passed the fortieth year of his life; it was not till 1846 that the contract was signed with M. Hachette, whose liberal support was indispensable to the author. From that time forth the collection of authorities and materials, and the art of classification, which was the result of numerous experiments (some of them being abortive), occupied about thirteen years. Several persons were employed to read and extract, with a precise reference, passages from the whole body of the French classical writers from the sixteenth to the nineteenth century; to which M. Littré added, from his accurate knowledge of the old French chronicles and poets, a multitude of curious archaic examples from the thirteenth century downward. The arrangement of this enormous mass of materials seems to have been entirely done by M. Littré himself. The work of printing began in September, 1859, and was completed in July, 1872. Every proof passed under the eyes of four careful correctors, besides the printer's reader, and the final revision of the author. It took about two months to carry a sheet through the press. In the course of this vast operation 292 quarto pages of three columns each were added to the proofs. Twice the composition and execution of the work were interrupted by a revolution and a war; but, by assiduous efforts, M. Littré always kept

ahead of his compositors and correctors. We must leave him to relate in his own words how this was effected. The volume entitled "Glanures" contains a paper, written in the last hours of his life, entitled "Comment j'ai fait mon Dictionnaire," which tells the wonderful story of his literary existence: "My rule of life included the twenty-four hours of the day and night, so as to bestow the least possible amount of time on the current calls of existence. I contrived, by sacrificing every superfluous indulgence, to have the luxury of a dwelling in the country and another in town. My country abode was at Ménil-le-Roi, near Paris, a small old cottage with near an acre of productive garden, which *dapibus mensas onerabat inemptis*, as it did to the old man in the Georgics. There I was master of my time. I rose at eight; very late, you will say, for so busy a man. Wait an instant. While they put my bedroom in order, which was also my study, I went down-stairs with some work in hand. It was thus, for example, that I composed the preface of the 'Dictionary.' I had learnd from Chancellor d'Aguesseau the value of unoccupied minutes. At nine I set to work to correct proofs until the hour of our mid-day meal. At one I resumed work, and wrote my papers for the 'Journal des Savants,' to which I was from 1855 a regular contributor. From three to six I went on with the 'Dictionary.' At six punctually we dined, which took about an hour. They say it is unwholesome to work directly after dinner, but I have never found it so. It is so much time won from the exigencies of the body. Starting again at seven in the evening, I stuck to the 'Dictionary.' My first stage took me to midnight, when my wife and daughter (who were my assistants) retired. I then worked on till three in the morning, by which time my daily task was usually completed. If it was not, I worked on later, and more than once, in the long days of summer, I have put out my lamp and continued to work by the light of the coming dawn. However, at three in the morning I generally laid down my pen, and put my papers in order for the following day—that day which had already begun. Habit and regularity had extinguished all excitement in my work. I fell asleep as easily as a man of leisure does; and woke at eight, as men of leisure do. But these vigils were not without their charm. A nightingale had built her nest in a little row of limes that crosses the garden, and she filled the silence of the night and of the country with her limpid and tuneful notes. O Virgil! how could you, who wrote the Georgics, describe as a mournful dirge, *miserabile carmen*, those glorious strains?"

We have never heard of another example of severe labor of the brain carried on systematically for seventeen or eighteen hours a day for so many years. But M. Littré, who was himself a great medical authority, is of opinion that it did him no harm. He was past forty when he began this work; he was fifty-nine when he began to print the Dictionary; he was seventy-two when he completed it; and he

lived to be near eighty. To these details we will only add that he abstained from every kind of luxury and indulgence, except a holiday of one month in the year, spent on the coast of Brittany. He lived on the smallest pittance on which life could be supported. Hachette allowed him a hundred pounds a year, but half of this sum went to his wife and daughter. He had previously saved forty thousand francs, but that was lost in the Revolution of 1848. The publisher's advances to the author amounted to no more than forty thousand francs, a sum which was eventually repaid out of the profits of the sale. But until the completion of the work the sale was small, and these thirty years of unexampled labor were at the time wholly unproductive. Happily, M. Littré's life was sufficiently prolonged for him to witness the triumphant success of his great undertaking. It brought affluence to his declining years; it placed him on the seats of the French Academy; it has given him fame far beyond his modest aspirations and his simple tastes. We have been informed that fifty thousand copies of the Dictionary have been sold; if this is the fact, it is without a parallel for a publication of this price and magnitude.

It is impossible for us within our present limits, and with the task we have now before us, to attempt a critical examination of this great work. Suffice it to say that the conception was as original as the execution is marvelous. The French language has been spoken and written for seven hundred years; like all languages, it has undergone vast transformations in that period; like all living languages, it is still undergoing a process of perpetual evolution. The Dictionary of the Academy is the standard of the accepted and existing language of France; it excludes archaisms, it condemns neologisms, it gives no references or derivations. M. Littré's design is far broader and more vast; it is based on the historical growth of the language, and it includes the history of every word in the language from its first occurrence, its etymology, and its various meanings, down to its modern use. The period of what is termed contemporary or classical French dates from Malherbe, a little more than two hundred years back; but, with few exceptions of recent date, every word has a tradition of centuries behind it. Thus, each article in M. Littré's Dictionary includes, first, the word; then its pronunciation; then the conjugation of the verbs, if irregular; then the definition of the various meanings of each word, illustrated by quotations from the best authors of the seventeenth, eighteenth, and nineteenth centuries, all textually referred to so that they can be found; and these meanings are scientifically arranged, always proceeding from the more simple and concrete to the more abstract and metaphorical. This classification of meanings is the most remarkable feature in the work, because it is executed with an extraordinary amount of philosophical discrimination. Take, for example, the word *Nature:* M. Littré dissects and unravels it into twenty-eight shades of meaning, and each of these is verified by ap-

propriate quotations and authorities. Such an article takes the reader into the depths of philosophical speculation; in tracing the history of a word he follows the history of thought. The verb *passer* runs to no less than sixty-six meanings, many of them amusing, proverbial, anecdotical. The word *faire* in French represents the two English verbs to *make* and to *do*. It consequently covers an immense field of action. M. Littré defines it as the word "qui dénote toute espèce d'opération qui donne être ou forme." He traces it through eighty-two shades of meaning, and the article he devotes to it is an essay of no less than eight quarto pages. Hence this Dictionary becomes attractive and even fascinating. Like Forcellini's Lexicon, which it most resembles, there is scarcely a passage or marked expression in the French classics which is not cited in it; but Forcellini and Ducange were dealing with dead or expiring languages; M. Littré had to force his way through the Babel of modern literature and society.

We now pass from the book to the man, whose life is scarcely less remarkable than the work to which he devoted it, and here we shall avail ourselves of the guidance of M. Pasteur in his discourse. Emile Littré was born in Paris, February 1, 1801. His father was an artilleryman of the first Republic, who had adopted with passion, both in politics and religion, the stern theories of the Revolution of 1791, and defended them in the patriotic army. He transmitted these opinions to his son, who inherited the same austerity of principles, tempered, however, by great natural benevolence. His mother was a woman of the same energetic stamp, though uneducated. Sainte-Beuve described her as "a Roman matron." The lad was educated at the Lycée Louis-le-Grand, his father having a small appointment in the office of inland revenue in Paris. The elder Littré learned Greek, and even began Sanskrit, to assist in the education of his son. On leaving college the young man acted for a time as secretary to M. Daru; but he desired to follow the medical profession, and had all but completed his hospital training, when his father died, leaving him too poor to take his degree and to enter upon practice. Accordingly, he never did practice medicine, except gratuitously among the poor of his village. Yet such was the medical reputation he acquired by his subsequent writings, that, as we have been informed, he was ultimately elected a member of the Medical Council of Paris. At this early stage of his life, in 1831, he was compelled to fall back on the humble occupation of a teacher of foreign languages and mathematics, and a translator of articles for the "National" newspaper, which made him acquainted with Armand Carrel. Meanwhile his mind, conscious of its strength, yet modest to excess, formed vast and varied projects, which he hesitated to execute. Such was the mastery he had already acquired over the sources of the French language, that he amused himself by translating a book of the "Iliad" into French verse of the thirteenth century. He also translated the elder Pliny, and in 1834 plunged into a greater

work, a translation and edition of the writings of Hippocrates, for which his medical studies had prepared him. Indeed, he continued to write on medical subjects, in which he always took the strongest interest. "Though I have studied medicine," he said, "without having made any practical use of it, I would not exchange for anything else this fraction of knowledge which I have acquired by persistent labor."

The use he did make of it was to watch over the health of his village, for to a rigorous austerity of life he united the utmost tenderness of heart, and, although he wandered far from all theological belief, his life was one constant example of self-denial, of consideration for others, and of what might be called the religion of duty. No monk ever lived on simpler fare or in a humbler abode. That cottage still remains in the state in which he left it, and over the table, as a visible symbol of reverence and toleration, hangs a picture of our Saviour. We have already related in his own language the extraordinary labor in which his days and nights were spent over the Dictionary. Yet his door was never closed against the visit of a friend; he continued to take part in the transactions of the branch of the Institute to which he belonged; and, yielding to the earnest solicitation of the widow of Auguste Comte, he consented to write, in addition to his other work, a biography of that personage.

Born and educated upon the devastated soil of the French Revolution, Littré had entered upon life without religious opinions; indeed, like the elder Mill, his father had deliberately withheld them from him. But at the age of forty he read the "System of Positive Philosophy" by Auguste Comte, and he thus described the impression he received from it: "This book subjugated me. A conflict arose in my mind between my old and my new opinions; the latter triumphed. I became a disciple of the Positive Philosophy, and I have remained so. For the last twenty years I have been an adept of this philosophy. The confidence I feel in it has never been shaken. Employed on very different subjects—history, language, physiology, medicine, erudition—I have constantly used it as a sort of tool which traces for me the features, the origin, and the conclusion of each question. It suffices for everything; it never deceives me; it always enlightens me." This is the best testimony ever borne to the value of M. Comte's philosophy; and it is borne by an eminent man, and that man a Frenchman. M. Comte has had but little honor in his own country; he was detested, despised, and to some extent persecuted in France while he was alive; and, with the exception of M. Littré, we have never heard that he has obtained any eminent disciple among his own countrymen.

From England, on the contrary, he received solid proofs of sympathy and interest, for he lived on an English annuity; and since his death his works have been carefully translated, and his opinions

adopted by some of the young and active minds of the present times. The French even deny him the merit of originality, and repudiate his system, probably because they know more of the man than we do. But we shall leave M. Pasteur to discuss it: "The fundamental principle of Auguste Comte is to set aside all metaphysical inquiry into first and final causes, to reduce all ideas and all theories to fact, and to restrict the character of certainty to experimental demonstration. His system includes a classification of the sciences, and a pretended law of history expressed by the assertion that the conceptions of the human mind pass successively through three states—the theological, the metaphysical, and the scientific or positive.

"M. Littré was full of praises of this system and of its author. In his eyes Auguste Comte was a man destined to hold a great place in posterity, and the positive philosophy was one of those products of a century or more which change the level of human thought. If he had been asked what he esteemed most in the laborious efforts of his life, Littré would doubtless have replied that it was his sincere and persevering apostolate of positivism. It is not uncommon to find the most learned of men deluded as to their own chief merits. I confess, therefore, that I have formed an estimate of the work of Auguste Comte differing widely from that of M. Littré. The causes of this divergence are the result of the very nature of the inquiries which occupied his life and of those which have exclusively occupied mine.

"The labors of M. Littré were directed to researches in history, language, and scientific and literary erudition. The subject of these studies lies entirely in facts belonging to the past, to which nothing can be added, from which nothing can be subtracted. The method of observation to be followed in them can seldom lead to strict demonstrations. Scientific experiment, on the contrary, admits no others.

"The experimentalist in the conquest of nature is continually opposed to facts not yet manifest, and which exist in the potential rudiments of natural laws. The unknown, within the limits of the possible, and not of the past, is his domain; and to explore it he employs that marvelous experimental method, of which it may be said with truth, not that it suffices for all things, but that it rarely deceives those who use it aright. The mistake of Auguste Comte and M. Littré was to confound this method with the simple method of observation. Unused to experimental philosophy, they use the word 'experience' in its ordinary signification, which is by no means its meaning in scientific language. The daily tasks of the man of science lead him to seek the idea of progress in an idea of invention. I find no invention in positivism. The mere gradation of the human intellect and the classification of the sciences have no claim to the title."

M. Littré found a certain repose of mind in the absolute denial by the positivists of all metaphysical truth. He was, in fact, what is now

called an agnostic. Without denying the existence of God and the immortality of the soul, he dismissed them from his thoughts, as subjects incapable of scientific demonstration. To this M. Pasteur replies :

"As for myself, holding that the words 'progress' and 'invention' are synonymous, I ask by what new philosophical or scientific discovery the soul of man can be torn from these lofty themes. They seem to me to be eternal, because the mystery that infolds the universe, from which they emanate, is itself eternal. . . .

"Positivism errs in more points than in its mistaken method. The thread of its argument, though apparently close enough, has in it a vast fault, which the sagacity of M. Littré might have detected. He frequently remarks, in speaking of positivism from the practical point of view, 'I call positivism all that is done by society to promote social organization on a scientific basis, which is the positive conception of the world.' I accept this definition if it be rigorously applied ; but the great and manifest fault of the system is that it omits from the positive conception of the world the most important of positive ideas—that of the infinite.

"Beyond this starry firmament what is there? More skies and stars. And beyond these? The human mind, impelled by an irresistible power, will never cease to ask itself, what lies beyond? Time and space arrest it not. At the farthest point attained is a finite boundary, enlarged from what preceded it ; no sooner is it reached than the implacable question returns, returns for ever in the curiosity of man. It is vain to speak of space, of time, of size unlimited. Those words pass the human understanding. But he who proclaims the existence of the infinite—and no man can escape from it—comprehends in that assertion more of the supernatural than there is in all the miracles of all religions ; for the conception of the infinite has the twofold characters that it is irresistible and incomprehensible. We prostrate ourselves before the thought, which masters all the faculties of the understanding, and threatens the springs of intellectual life, like the sublime madness of Pascal. Yet this positive and primordial conception is gratuitously set aside by positivism, with all its consequences on the life of human society.

"The conception of the infinite in creation is everywhere irresistibly manifest. It places the supernatural in every human heart. The idea of God is a form of the idea of the infinite. As long as the mystery of the infinite weighs upon the mind of man, temples will be raised to it, be the object of adoration Brahma, Allah, Jehovah, or Jesus. Metaphysics are but the study of this commanding notion of the infinite. The same ideal conception is the faculty which, in presence of beauty, suggests the perfection of beauty. Science and the true passion for discovery are the effects of that intense desire to know, which is inspired by the mystery of the universe. And what is

the true source of human dignity, of liberty, of modern democracy, but the conception of an infinite power, before which all men are equal? 'There must be,' says M. Littré, 'some spiritual bond of humanity, without which society would lapse into isolated families or hordes, and be no real society at all.' This spiritual bond, which he placed in a sort of subordinate religion of humanity, can only consist in the lofty conception of the infinite, because the spiritual bond must be one with the mystery of the world."

The genius of M. Littré was essentially analytical. In that spirit he delighted to trace the uses of words and language to their roots and filaments; and he performed that task with consummate ability. But we discover in his writings no power of constructive reasoning. On the contrary, he was apt to mistake mere reveries and phantasms for the laws that govern society and the human mind. Thus in 1850 he announced "that peace for the next five-and-twenty years was foreseen by sociology, and, indeed, that peace was to last throughout the present period of transition, at the end of which a republican confederation would unite the west of Europe and put an end to armed conflicts." In 1878 he was obliged to confess that all his forecasts were mere delusions. In the interval four wars had broken out, and the great monarchies of Germany and Italy had consolidated their power at the expense of France. We have a profound respect for M. Littré as a philologist, but he certainly was not a politician nor a philosopher. That new-fangled term "sociology" covers a multitude of false speculations and puerile blunders.

M. Taine is not a disciple of Auguste Comte, and he professes no great respect for that positive philosopher. He is rather a follower of Condillac and the skeptics of the last century; and, as we have had occasion to point out in reviewing his works, he attributes, like the late Mr. Buckle, a sovereign power to matter over mind, and to external circumstances over the formation of individual and national character. We have not forgotten his caricature of English literature, which he ascribes to the carnivorous tastes of the Anglo-Saxon. He judges of the genius of a nation by its diet and its climate. On the occasion of his own reception at the Academy, in January, 1880, M. Taine delivered an *éloge* of his predecessor, M. de Loménie, which is really a masterpiece, unexceptionable in taste and style. No one has drawn a more faithful and graceful picture of the French society of the last generation, such as gathered round Madame Récamier at the Abbaye-aux-Bois. But these things have passed away. M. Dumas, the eminent chemist, in his reply to the new academician, touched on the vagaries of a more recent period, and did not leave M. Taine's materialist philosophy unnoticed.

He told him that "the fanatics of the naturalist school, upsetting language and placing the physical above the moral side of things, contend that, to judge of a man's work, you must trace his innermost life,

ascertain whether he was born on a calcareous or a granite soil, learn whether his ancestors and himself have drunk wine, cider, or beer, or eaten meat, fish, or vegetables—nay, you must penetrate the meanest details of his existence, and descend from the heights of criticism and from a scientific system to the gratification of a paltry curiosity."

This sarcasm was not ill-directed to its mark, but M. Dumas went on: "The physician and the naturalist may teach what is physical in man, that his nerves are sometimes instruments of pain, and that his body is but dust. That is their business. But philosophy and eloquence should cast their mantle of purple and gold over the baser aspects of life. It is their business to strengthen the heart of man and raise his soul to immortality. That is what you tell us has been done by Mr. Tennyson, the greatest poet of his time, if not of his country, whom some of his admirers place above Byron and not far below Shakespeare."

And the old man eloquent went on: "The philosophy of nature played a considerable part in the events of the last century. The schools of Greece thought they had penetrated to the elements of all things; the Roman poets, in turn, regarded themselves as the interpreters of creation; Diderot and his rivals boasted that they possessed the universe. But the discoveries of science in our own age prove that none but the ignorant can suppose that the whole book of wisdom has been revealed to us. The source of life and its essence are unknown to us. We have not seized that mysterious link which connects the body with the mind, and constitutes the unity of individual man. We have no right to treat man as an abstract being, to disdain his history, or to attribute to science an influence over the direction of the moral axis of the world, which its progress does not justify. We have, it is true, conquered the earth, measured the track of the planets, calculated the mechanism of the heavens, analyzed the stars, resolved the nebulæ, and followed the eccentric course of comets; but beyond those stars, whose light is centuries in reaching us, there are other orbs whose rays are lost in space; and farther, farther still, beyond all limits and all computation, are suns which we shall not behold, and innumerable worlds hidden from our eyes. After two thousand years of effort, if we reach the utmost extremity of the universe, which is but a point in the immensity of space, we are arrested on the threshold of the Infinite, of which we know nothing. 'The nature of man, his present and future existence, are mysteries impenetrable to the greatest genius, as well as to the rest of mankind,' said D'Alembert, at the height of his fame. 'What we know is but little,' said Laplace on his death-bed. Those were the last words of the illustrious rival of Newton. Let them also be mine."

The lofty idealism of these speakers repudiated alike the Comtism of M. Littré, the materialism of M. Taine, and the destructive criticism of M. Renan. It is no less opposed to that miscalled philosophy of

the senses which has found of late years so many able advocates among the men of science and the younger thinkers of England. The perceptions of the senses are undoubtedly the only guides we possess to a knowledge of the material world, and the inferences drawn from them by the faculties of the understanding are the legitimate conquests of physical science. But they entirely fail to explain the higher functions of the intellect, which are the domain of metaphysics; still less do we derive from the senses the moral laws of justice, of truth, of charity, of conscience; and least of all that conception of the supernatural and the infinite which it is the glory of man to trace in nature and in the emotions of the soul. Man alone, said Goethe, is a religious animal, and those who would degrade his nature to that of the brutes, begin by extinguishing in him the sense of religion.

These are, in other words, the sentiments expressed by M. Dumas and M. Pasteur. And who are they who hold this language? The one is a chemist, conversant with all the known properties of natural bodies and the marvelous combinations of the atomic theory which reduces them all to a few primitive elements. The other is a physiologist who has refuted the theory of spontaneous generation, and established on a solid basis that life alone can impart life. They have both traveled as far on the road of natural science as it will take them; they have even enlarged the bounds of physical knowledge. But, arrived at that term of man's labor, they acknowledge that an infinite horizon of thought, of action, of forces, and of power lies beyond the scope of sensuous observation. He studies Nature with a careless eye and a benighted mind who does not perceive that the supernatural lies in it and above it. For when all is said that science can teach, and all is done that skill can achieve to cultivate the earth and bring forth its fruits, one gift remains without which everything else were vain—that gift which the Supreme Creator has reserved absolutely to himself—that gift which man and every living creature can take away, but can never restore—that gift without which this earth would be no more than the cinder of a planet—the mystery and the miracle of LIFE. Life is everywhere; without life nothing would exist at all: matter would be the *caput mortuum* of the universe. With the diffusion of life creation begins; and of that act all but a supernatural power is incapable. The seed of cummin you commit to the earth includes it; the single grain of wheat shoots up, not only to reproduce itself, but to multiply its ears a hundred-fold and in successive generations, millions upon millions of times, and to nourish a world; the acorn carries in its little cup a thousand years of vitality; the midge and the butterfly that sport for a day upon the rushes and the blossoms enjoy it; the laborious earth-worm that builds up the fertile soil of our fields and gardens has it; it ascends through all the scale of existence until it arrives at Man, a being capable of conceiving Infinite Power and hopes

of an everlasting future. Yet who shall say what Life is? What is the value of a system of philosophy which denies or discards the only rational solution of the very first problem and condition of our own existence?—*Edinburgh Review.*

THE CHINESE: THEIR MANNERS AND CUSTOMS.

THE manners and customs of the Chinese—an extensive subject, and our canvas a narrow one.

But where to begin?—Domestic life, religion, war, courts of justice, schools, literature, are all alike almost unknown. Be chance our guide. A paper is lying open on our table: it is the "Times." Let us follow the order of its articles and commence at once with the article of births, marriages, and deaths.

Births will afford us but little subject for remark. Let us, however, suppose that the solemn bath appointed for the third day is over, which would seem to be almost a Chinese baptism, and the mother to be convalescent. If the offspring be a girl, there will probably be no rejoicing, but, if a boy, the mother will go in state to the temple frequented by her family and offer thanks to Tien How, the queen of heaven. The only time it was our fortune while in China to see a native lady of any standing was on such an occasion. A wife of Howqua, the son of the celebrated Hong merchant, had gone to the Temple of Honam to return thanks for the birth of a son. The shrine in the temple which she was visiting had been founded by the elder Howqua in honor of his ancestors: it was a lofty hall with roof open to the beams, closed in the rear and at the sides, but in front opening with richly carved doors on a raised terrace surrounded by a stone balustrade and overlooking a square, turfed inclosure containing two or three fine specimens of the Chinese banyan, or *Ficus religiosa*, and a pond of water covered with the broad green leaves and rose-tipped flowers of the lotus, the sacred plant of Buddha, who is often represented as seated on its open flower. Crossing this pond and skirting it were a bridge and gallery of massive stone carving, corresponding with the balustrades and communicating with the terrace. On the opposite side of the gallery was seen the rear of another shrine, colored of a deep vermilion like the one in front, with its high arched roof sweeping down like the curved outline of a Tartar tent (from which the Chinese style of architecture is supposed to be borrowed), and adorned with dragons, birds, and dolphins in glazed pottery of the brightest colors. Down either side stretched a line of gloomy cloisters communicating with the rest of the building. At one end of the terrace were two or three small tables arranged with viands placed

upon them and surrounded by a considerable party of Chinese, among whom we noticed several females standing, evidently in attendance upon some lady, as in China the servants are almost invariably of the other sex. Knowing the scruples of the Chinese against admitting foreigners into the presence of the female members of their families, we turned back, and were on the point of leaving that part of the temple, no little disappointed at being unable to see the whole of the building, when two members of the group, one of whom was a son of Howqua, came forward and requested us to continue our examination, if we wished. We did so. The shrine at which the ceremony was going on had been decked with flowers, while on the long, counter-like altar in front of the figure of the goddess, between the jars of porcelain and bronze half filled with sandal-wood ashes in which sticks of incense were burning, and upon two square pedestals in front of the altar, were piled up pyramids of fruits and sweetmeats. On either side of these pedestals were two of smaller size, on each of which was placed a book apparently of religious service, and by its side a small wand and a hollow, red, kidney-shaped gourd, which when struck gave a hollow and not unmusical sound, each blow upon it marking the repetition of a prayer. These, as it were, formed the lecterns of the officiating priests ; and between them, facing the central vase on the high altar, were placed a cushion and a mat on which the fair devotee might kneel and perform the *kotou*, or ceremony of kneeling and touching the ground with the head at certain periods during the service. At either side of the central door of the shrine stood a large bronze vase heaped with silvered paper formed into boxes about the size and shape of steel-pen boxes, and emblematical of bars of Sycee silver, which is burned at the conclusion of the ceremony as an offering to the queen of heaven.

On passing out of the shrine, still accompanied by the two Chinese who had joined us, we passed near the banqueting party, when the lady rose, supported by two of her servants, and, crossing her hands, saluted us in the Chinese fashion. Of her beauty I can say nothing ; neither my companion nor myself could remember anything save a face painted *à la Chinoise*, and hair tied up in the usual tea-pot form, dressed with magnificent pearls, jade ornaments, and natural flowers. The golden lilies, as the inhabitants of the Flowery Kingdom call the crippled feet of the higher classes of their women, and the splendidly embroidered robes, attracted our attention far more than the eyes and features, which doubtless ought to have been our only consideration.

It is after this festival, not always, of course, celebrated with the magnificence we have described, that the relatives of the child present it either with plate, or bangles of silver or gold, on which are inscribed the characters signifying long life, honor, and felicity. It is also at this period that it receives its "milk-name," or the pet name by

which it is known in its family, the name by which it is known to others being only given to it at the completion of its fourth year, when its education is supposed to commence.

We have all heard the Chinese charged with infanticide. We believe that crime to be less prevalent with them than it is with us. If children are ever exposed, as has been seen on a way-side altar near Honam, we believe that bitter want and a hope that charity would provide for the child better than the mother could have been the moving causes. As a general rule, self-interest acts as the strongest bar to this vice. That the life of the male children should be preserved is most important, as the Chinese law will compel the sons to maintain their parents, and, in the event of all the sons dying, no one would be able to offer that worship at the tomb of the father and mother on which their happiness in another state is supposed to depend. With the girls preservation is almost as important, and they are a marketable commodity, either as wives or as servants. Indeed, it is no very rare thing to see a basketful of babies sent down from Canton to Hong-Kong for sale at prices ranging from two to five dollars. These are all girls; and the purchase of one or more of them is generally the first investment that a Chinese Aspasia makes of her earnings, a speculation sure ultimately to pay a very large interest on the money sunk.

In denying the existence of infanticide it is necessary to make one exception. This is among the Tan-kia, or boat-population. These are a race of people of different descent and different religion from the Chinese, governed by their own magistrates, and so looked down upon by the other classes that no child of a boat-woman can compete in the literary examinations, or, whatever his ability may be, become an aspirant for office. This class is excessively superstitious, and we have heard it stated by missionaries that, when a child belonging to people of this class suffers from any lingering malady, and recovery becomes hopeless, they will put it to death with circumstances of great cruelty, believing it to be not their child but a changeling, and fancying that a demon has taken the place of their offspring for the purpose of entailing on them expense and trouble for which they could never get any return.

The next article we come to is *marriage:* hedged in with formalities in all countries, but in none more so than in China. As we have just been speaking of the Tan-kia people, let us take Dr. Yvan's account of one of their marriages, and have done with them:

> "In harvest-time," says the doctor, "any man of their class who wishes to marry goes into the next field and gathers a little sheaf of rice, which he fastens to one of his oars. Then, when he is in presence of the Tan-kia girl of his choice, he puts his oar into the water, and goes several times round the boat belonging to the object of his affections. The next day, if the latter accept his homage, she, in her turn, fastens a bunch of flowers to her oar, and comes rowing about near her betrothed."

The relatives on both sides assemble on board the girl's boat; there is a general feast, a great firing of fire-crackers, beating of tom-toms and burning of joss-paper to frighten off evil spirits, the cup of union is drunk together, the bride is taken to her new floating home in a closed sedan of red and gold, and the ceremony is at an end. The rice in the above case is emblematic of the support promised by the man, the flowers of the happiness offered by the woman.

Among the pure Chinese, and especially among the higher classes, the affair is a much longer and more serious one. From the almost Turkish strictness with which females are secluded, it is comparatively rare that a couple see each other previous to betrothal, and still more so that there should be any acquaintance between them. This has given rise to the necessary employment of a character equivalent to the *bazvalan* or marriage-broker of ancient Brittany, to Mr. Foy's Parisian Matrimonial Agency Office, or the daily marriage advertisements of our own papers. If your wish is for marriage in the abstract, the broker will find you a fitting partner first, and negotiate the transfer after. If you are less purely philosophical, and wish to consult your own tastes as well as the interests and increase of the nation, you are only to name the party, and the broker becomes your accredited embassador. There is, however, one preliminary point to be ascertained. Has your intended the same surname as yourself? If so, it is a fatal difficulty, as the laws of China would not permit the marriage. If, however, she is Chun and you are Le, or she is Kwan or Yu, and you rejoice in any other patronymic monosyllable, the next step is for the broker to obtain from each a tablet containing the name, age, date and hour of birth, etc. These are then taken to a diviner and compared, to see if the union promises happiness; if the answer is favorable (and crossing the palm with silver is found to be as effectual with fortune-tellers in China as it is elsewhere), and the gates are equal, that is, if the station and wealth of the two families are similar, the proposal is made in due form. The wedding-presents are then sent, and, if accepted, the young couple is considered as legally betrothed. A lucky day must next be fixed for the wedding, and here our friend the diviner is again called upon. Previous to the great day the bridegroom gets a new hat and takes a new name, while the lady, whose hair has hitherto hung down to her heels in a single heavy plait, at the same time becomes initiated into the style of hair-dressing prevalent among Chinese married ladies, which consists in twisting the hair into the form of an exaggerated tea-pot, and supporting it in that shape with a narrow plate of gold or jade over the forehead, and a whole system of bodkins behind it. On the wedding morning, presents and congratulations are sent to the bridegroom, and among the rest a pair of geese; not sent, as we might imagine, by some wicked wag or irreclaimable bachelor as a personal reflection on the intellectual state of his friend, but as an emblem of domestic

unity and affection. The ladies, too, in China as well as elsewhere, indulge in a little fashionable crying on the occasion, and so the relatives of the bride spend the morning with her, weeping over her impending departure, or, more probably, their own spinsterhood. They do not, however, forget to bring some contributions for her trousseau. In the evening comes the bridegroom with a whole army of his friends, a procession of lanterns, a long red cloth or silk tapestry embroidered with a figure of the dragon, borne on a pole between two men, and a large red sedan covered with carving and gilding, and perfectly close. In this the bride is packed up securely out of sight, and the whole procession, preceded by a band of music and the dragon and closing with the bride's bandboxes, starts for home. On arrival she is lifted over the threshold, on which a pan of charcoal is burning, probably in order to prevent her bringing any evil influence in with her. She then performs the *kotou* to her husband's father and mother, worships the ancestral tablets of her new family, and offers prepared betel-nut to the assembled guests. Up to this time she has been veiled, but she now retires to her chamber, where she is unveiled by her husband; she then returns, again performs obeisance to the assembled guests, and partakes of food in company with her husband; at this meal two cups of wine, one sweetened, the other with bitter herbs infused in it, are drunk together by the newly married pair, to symbolize that henceforth they must share together life's sweets and bitters. The bride then retires, escorted by the matrons present, some one of whom recites a charm over her, and arranges the marriage-couch. The next morning the gods of the household and the hearth are worshiped, and the six following days are devoted to formal receptions at home of different members of the two families or equally formal visits paid to the family of the bride. During the whole of this period she still travels in her red-and-gold sedan, and is still escorted by her band of music and dragon.

Such are the ceremonies with which the chief or number one wife is espoused, and of this rank there can be but one. Taste and depth of pocket give the only limit to the number of subsidiary wives that may be taken. These are married with far less ceremony than the first, are often from a different class of society, being literally purchased, and act to a certain extent as servants or attendants to the chief wife. They are, however, legal wives, with recognized rights and position; their children are legitimate, and inherit in equal shares with those of the first wife. Indeed, this last is considered as the mother of the whole family, and the children are bound to display toward her more reverence than even toward their natural parent.

But even in the Flowery Land, people sometimes find that the bitter predominates over the sweet in the cups of alliance, and that the geese borne in the marriage procession are emblematical of something else besides domestic affection. In a word, they occasionally want to

be unmarried. And really they have made a very fair provision for enabling themselves to loose the knot. Not only do they admit such grounds of divorce as would satisfy Sir Cresswell Cresswell, but they add to them inveterate infirmity, disrespect to the husband's parents, thieving, and, most comprehensive class of all, ill-temper and talkativeness. However, if the husband has acquired property since his marriage, if the wife has no parental home to which she may return, or if she has mourned for her husband's parents, divorce can not take place. It is one of the many exemplifications of the Chinese maxim that the laws should be severe, but tempered with mercy in their administration.

There is, however, another dissolution of marriage over which law has no power—that which is effected by the hand of death. The widow is not forbidden to remarry, but by so doing she loses many privileges, and her conduct is considered somewhat light and irregular. Nature, however, will occasionally speak louder than fashion, and it may be worth while to repeat the tale told by Chwângtsze, the great Chinese philosopher.

A Chinaman died soon after his marriage with a young and lovely woman. As he was dying, the wife was loud in her protestations of grief, and her determination not to marry again. The husband was not unreasonable; he only asked that if she did take another spouse she would wait till the earth upon his grave was dry. He died and was buried; and many a young and handsome bachelor of the province of Shantung was present at his funeral. She listened to no suitor, for woman's heart is tender, and she could not so soon forget the lost one. Daily she stole to his grave. She wept, but no tear fell upon the soil, she took good care of that. At last, after a few days, Chwângtsze happened to pass, and saw her fanning, not herself, but the damp earth. He asked the reason. She told him of her husband's last request, and begged him to assist her. She offered him a fan to assist her, and there they sat to fan away the moisture: the grave was *so* long a-drying!

Poor Chwang! He was not much more lucky himself. He did not take the widow, but neither did he take warning. The geese were carried for him, and were *very* typical of *himself*. He had nothing to do for it at last but to quit political life, in which he had gained some distinction, and turn philosopher. But we will have "no more scandal about Queen Elizabeth," lest rosy English cheeks should take the part of China's golden lilies, as we have known widows at home almost in as great a hurry as those of the province of Shantung.

But even to the poor Chinaman death must come at last, even though there is no paper in Canton, so far as we know, to furnish a notice of his life and death, and to publish an abstract of his will, as is the case in more civilized countries. To him it comes armed with few terrors, so long as he leaves behind him male offspring to make

the prescribed offerings at his tomb. We have stood by many a Chinese death-bed, and though the dying man might "prattle o' green fields," and fancy himself once more surrounded by his friends amid the peach-groves of Hiang Shan, while his frail body was tossing on the stormy waves of the Indian Ocean, yet there was no sign of dread with regard to the future that awaited him. But there, far out at sea, there was no opportunity for witnessing the ritual of death But one brief hour after the eye has glazed, and the jaw has fallen, the canvas-shrouded and shotted corpse takes its last plunge into the blue ocean depths, without a prayer, without a rite save the few *cash* sprinkled by his remaining comrades over his watery tomb.

On shore a very different spectacle is presented. As the last hour draws near, the relatives wander round the house with cries, the gong is incessantly beaten, and packet after packet of fire-crackers gives out its short, sharp series of detonations, sounding like irregular platoon-firing, to frighten away the evil spirits supposed to be watching round the house to seize the departing soul; while, within, upon the filming eye the smoke of the ever-burning incense mingles with death's gray shadow. The eye has closed, the spirit has departed, and now every door and window is flung wide open, and the "keen" rises wildly to recall the wandering guest to its deserted tenement. And now the death is announced to all the relatives; the door is hung with white drapery, and down each lintel hangs a scroll of white, on which appear funereal inscriptions in blue. Large blue-and-white lanterns are hung on either side of the entrance, and probably a bamboo portico, thatched with matting, is erected to preserve lanterns, inscriptions, and garlands from the weather. Should it be a parent who has passed away, two figures of the stork, the emblem of longevity, appear amid the decorations. The relatives of the deceased, robed in white, and with white cloths bound about their heads, now go in procession to the nearest spring or river; before them is supported the nearest heir of the deceased, wearing a white veil, showing signs of the deepest affliction, and bearing in his hand a bowl in which are two copper coins, whose united value is about half a farthing. This company, uttering the most dismal howls, and having in its train musicians whose performances are scarcely less doleful, has gone to purchase water to wash the dead. This ceremony having been performed, the body is dressed as in life, and placed in its coffin, which has previously been half-filled with quicklime. The lid is then put on, and cemented down, the whole of it being afterward highly polished, and the name of the deceased inscribed upon it.

The coffin, it may be as well to remark, is not a slight shell like those in use among us, but is either a hollowed tree or made in the form of one—the sides being rounded, and five or six inches in thickness. They are formed of very hard and costly woods, reaching occasionally the price of five hundred pounds. A handsome coffin is

considered as acceptable a birthday present as a son can offer to his father, and coffins so given are often preserved unused for years.

The coffin having been closed, it is covered with a white cloth, and watched for twenty-one days. During this period a small red board, with the names of the deceased in raised gilt letters, standing on a pedestal, and having an opening in the back, stands near the corpse, and is the object of a species of worship. It is called the ancestral tablet, and the hole in the back of it is intended to give admission to the spirit which is supposed to inhabit it. Should the family possess no available burial-ground, a diviner is consulted to choose some lucky spot for a tomb, which must be outside a town, and generally at some distance from it, a favorite spot being on the slope of a hill overlooking water. The tombs are formed in the shape of a horseshoe, consisting of a flat platform, under which the body is laid, surrounded by a raised wall, in the center of which a stone is placed, bearing a copy of the inscription on the ancestral tablet. Of course, the degree of ornament about the tomb depends in great measure on the rank and wealth of the deceased.

It by no means follows, however, that the body is buried at the close of the twenty-one days. The necessity to choose a lucky site, or the wish to transport the coffin to some distant burial-ground, may cause delays; and cases have been known where the delay has arisen from less justifiable motives. The Chinese law will not enforce the payment of rent so long as the body of the tenant's grandfather remains unburied in the house; nor is a man's property distributed till his funeral rites are completed. Hence the necessity which sometimes arises of taking legal steps to compel the burial.

Under different circumstances, the body of the great viceroy Yeh lay for months unburied. Let us give a description of his coffin, as it was not many months ago. A few rods outside the east gate of Canton, back from the street, stands an unpretending Taonist temple. A plain, unornamented gate opens the way into a long, narrow inclosure, which leads up to the shrine. The grounds seem deserted, save that one old Chinaman stands by the inner gate. He is no doorkeeper, but a street beggar. Yeh, the viceroy of Canton, has no doorkeepers now.

We pass beneath another archway, and up a passage hung with white, till we reach the apartment of the dead. Here, at length, we meet a few attendants, and a Taonist priest officiates as our guide. He leads us into a small hall about twenty-five feet by twenty, hung with blue cloth, on which funereal inscriptions are embroidered in white silk. An altar stands in the middle of the room, on which are placed some dozen bowls of cooked vegetables and piles of artificial fruit, and sticks of burning incense. Behind the altar is a tablet of white silk on which are embroidered the names and titles of the late viceroy, and behind this, again, a curtain hangs from the roof to the

ground. We raise and pass the curtain, and before us stands the coffin.

It is a plain box, but of great size, being twelve feet in length and four in thickness, each side consisting of a single slab of hard and costly wood brought from the province of Sze Chuen, far in the interior. Its cost was over fifteen hundred dollars. The man who for years ruled with a rod of iron—before whose mandate one hundred thousand heads fell in the execution-ground of Canton, whose diplomatic skill baffled for years the ministers of European powers, who, when his city was little better than a ruin and a desert, could not fight, and would not yield lest he should betray the prestige of the inviolability of Canton, after all his power, skill, and obstinacy—lies unhonored and almost unattended without the walls of the city which he could rule but could not save.

But we must hasten to a close. The grave having been fixed upon and the day for interment appointed, an altar is prepared in the room in which the body lies, and upon it are piled fruits and cakes, while in front of it we see a roast pig and a goat, the two latter being often made in lacquer-ware, and hired for the occasion. At the door are placed musicians, and from time to time large masses of silvered paper are burned at the entrance of the room. The body is then escorted to the tomb, all the mourners dressed in white, and the offerings, pig, goat, and all, form part of the pageant. But the principal object is the ancestral tablet, borne in a red shrine, and often accompanied by the figures of the household gods. On reaching the grave some religious ceremonies are performed, large quantities of silvered and gilt paper, and imitations of clothes, ships, etc., are burned, this being the readiest way of supplying the wants of the deceased, and forwarding his luggage to the spirit-land. The provisions furnish forth a feast, the coffin is interred, and the ancestral tablet borne back to the ancestral hall, where we will leave it, until the return of the period for the worship of the dead leads us back to the now closing grave.—*Temple Bar.*

SKETCH OF THOMAS SAY.

By J. S. KINGSLEY.

THOMAS SAY, the father of American zoölogy, was born in Philadelphia, July 27, 1787. Of his youth we know comparatively nothing. At an early age his parents, who were Quakers, placed him in a boarding-school under the control of the Friends, but Say did not take kindly to the instruction there provided, and acquired nothing but a most intense dislike for his teachers and for all ordinary branches of study. We are justified in ascribing this antipathy on his part to

the incompetency of the instructors, for in after-years Say showed an ability and a desire to learn which only the most repressing circumstances could have checked in his youth. Dr. Benjamin Say, the father, was an apothecary, in moderate circumstances; and young Say, after leaving school, was placed for a time behind the counter of his father's shop. After he had acquired some knowledge of the drug business, his father established him in trade with John Speakman, who was a member of the Academy of Natural Sciences of Philadelphia. Through Speakman, Say was induced to join the society, and with this act he began a life of science which has left its impress on every branch of natural history.

Say is considered as one of the founders of the Philadelphia Academy, but this is not exactly so. The academy was founded January 12, 1812, while Say was not elected to membership until April of that year, and his first attendance at the meetings was on April 16, 1812. What was his surprise, on entering the temple of science, to find the whole collection of specimens consisting of "some half a dozen common insects, a few madrepores and shells, a dried toad-fish, and a stuffed monkey!—a display of objects of science calculated rather to excite merriment than to procure respect." In fact, the academy was a social organization. This is shown by its first constitution, the preamble of which runs somewhat as follows (we quote from memory): "Whereas, we believe that we can obtain the same amount of pleasure and enjoyment, and at a less expense, around a common fireside and a common candle, than we can, each at his own fire and beside his own light," etc. With the advent of Say to membership this was soon changed, and the academy took its place among the scientific bodies of the world, a place which it has since occupied, though at times it has seemed to many of its friends that it was not doing the work which it ought. At present, under the able presidency of Dr. Leidy, it promises to take a higher stand than it ever has in the past.

Long before joining the academy, Say had acquired a familiarity with the forms of beetles and butterflies, but without reducing his knowledge to systematic order. Now, on joining a scientific society, he began those investigations on the American fauna which only ceased with his death. His partner, Speakman, fully sympathized with his passion for nature, and willingly did the labor of both in the shop, so that Say might devote all his time and energies to his favorite studies. Soon, however, this comfortable arrangement was brought to an end; the firm of Speakman and Say, in an evil hour, indorsed for friends, and, as a not unnatural result, came to grief. Say then took up his residence in the rooms of the society, making his bed on the floor, cooking his own food, and living at an expense at times not exceeding seventy-five cents a week. Had he, like Thoreau, given an account of his life at this time, it would have been an interesting chapter.

In 1816 he projected a work on American entomology, and in the next year six plates and the accompanying text were printed, but, from a lack of proper pecuniary support, the project for the time fell through, and the work was not properly published until a later date. In 1817 William Maclure and several other men of influence and property joined the academy, and through their efforts the "Journal of the Academy of Natural Sciences of Philadelphia" was started, and Say began his long list of contributions to knowledge. No complete list of his papers has been published, but the number aggregates nearly one hundred.

In 1818 Say, in company with William Maclure, George Ord, and Titian R. Peale, visited Georgia and Florida on a collecting expedition, and in the next year Say received an appointment as naturalist on Long's expedition to the Rocky Mountains, with Peale as an assistant. Peale is now the only survivor of either expedition, and at a ripe old age continues his scientific labors. The writer has heard many an anecdote of these trips from him. Long's expedition left Pittsburg, Pennsylvania, in May, on a steamboat built for the purpose, and proceeded as far as Council Bluffs, Iowa, where they spent the winter. During the next year they went to the Rocky Mountains, and, returning by another route, broke up at Cape Girardeau, Missouri, in November. Say appears to have been unfortunate on this expedition. At one time he was in charge of a party of five, making a trip on foot, when the pack-horse broke loose, and they lost both horse and baggage. Later, in charge of another party, he fell in with a number of Kansas Indians, and again lost horses, baggage, and camp equipments. The narrative of Long's expedition was published in two octavo volumes and folio atlas (Philadelphia, 1823), and some of Say's descriptions of the animals and "animal remains found in a concrete state" were given in foot-notes scattered through both volumes.

After the disruption of the party, Say, in company with one or two others, went to New Orleans, and soon returned to Philadelphia. His next trip was with Long's second expedition, which explored the sources of the Mississippi River; but, with the exception of this and one or two minor expeditions, the next few years were spent in Philadelphia.

In 1825 Say left his native city, never to return. William Maclure, who was a man of wealth and refinement, but considerably eccentric withal, had an idea that the "community system" was the true way of living, and, unlike some other dreamers, he proceeded to put his plans into execution. A large tract of land was purchased at New Harmony, Indiana, and there the community was started. Numbers of people, among them Thomas Say, Gerard Troost, and C. A. Lesueur, influenced by the arguments of the projectors and the glowing accounts of the happy life to be led by a people possessing all things in common and working for a common good, removed themselves and theirs to

this modern Utopia. The community, however, did not prosper; internal dissensions, as might have been expected, sprang up, and the aid of the courts was invoked. Maclure, utterly disgusted, went to Mexico, and left Say at New Harmony as his agent, to attend to the settling of the affairs of the community. This was not an agreeable task, but, without other means of support, Say was obliged to accept, and continued in this position until his death. This stay at New Harmony was not a period of scientific idleness on the part of Say, as the numerous contributions which proceeded from his pen attest.

At his death his collections and library came into the possession of the Philadelphia Academy. The insects were submitted to another entomologist for arrangement, but through an unpardonable neglect were allowed to go to complete ruin before their return to the academy, and the types of hundreds of species were thus irrevocably lost. The remainder of his types are principally the property of the Philadelphia Academy, where they are as religiously preserved with his own labels as are those of Linné and Fabricius in London, or of Herbst in Berlin. The number of new species which Say described has probably never been exceeded, except in the cases of those two exceedingly careless workers, John Edward Gray and Francis Walker, of the British Museum. There is this in Say's favor, which can not be said of the two just mentioned, that his descriptions are, almost without exception, easily recognized, and almost every form which he described is now well known. Working as he did without books, and without that traditional knowledge which obtains among the Continental workers, it was unavoidable that he should redescribe forms which were known before; but, owing to the clear insight he possessed, and the discrimination he exercised in selecting the important features of the form before him, his work has never caused that confusion in synonymy which many in much more favorable circumstances have produced.

Say's work was almost wholly the scientific description of the forms which came under his eye, and there is scarcely anything in his writings concerning the habits of animals, or which appeals in the slightest to the popular taste, and his language frequently is not of chaste and classic character. An extract from his "American Entomology" will illustrate this: "During the progress of Major Long's expedition up the Missouri, that enterprising and excellent officer intrusted me with the direction of a small party of thirteen persons, destined to explore the country on the south side of that extended river. After encountering many obstacles and privations, which it is unnecessary to enumerate, the party arrived at the village of the Konza Indians, hungry, fatigued, and out of health. Commiserating our situation, these sons of nature, although suffering under the injustice of white people, received us with their characteristic hospitality, and ameliorated our condition by the luxuries of repletion and repose.

Whilst sitting in the large earth-covered dwelling of the principal chief, in presence of several hundred of his people, assembled to view the arms, equipments, and appearance of our party, I enjoyed the additional gratification to see an individual of this fine species of *Blaps* running toward us from the feet of the crowd. The act of impaling this unlucky fugitive at once conferred upon me the respectful and mystic title of 'medicine-man' from the superstitious faith of that simple people."

Say's two principal works, published separately, were his "American Entomology" in three volumes (Philadelphia, 1824–1828), with fifty-four colored plates; and his "American Conchology," of which only six parts appeared previous to his death. The work on entomology was a credit to himself and to the printer, while almost the only merit possessed by the latter work was the fine plates from the pencil of Mrs. Say. Mr. Say's other published papers will be found in the "Journal of the Academy of Natural Sciences of Philadelphia," "Transactions of the American Philosophical Society," "Maclurean Lyceum," "Nicholson's Encyclopædia," "American Journal of Science and Art," "Western Quarterly Reporter," reports of Long's expeditions, and several papers which were published separately at New Harmony. His entomological papers have been collected and reprinted, with annotations, by Dr. J. L. Le Conte, in two octavo volumes (New York, 1869).

Besides the work which appears in connection with his own name, almost all of the publications of Prince Charles Lucien Bonaparte, while in America, were corrected and arranged for the press by Say. This and other work made such calls upon his time that almost all of his own work was the product of the midnight hours; and this, in connection with his wicked disregard of the demands of his stomach, so undermined his constitution that, when attacked by a fever in his Western home, he had not the strength to rally, and on October 10, 1834, he passed away.

According to the testimony of all who knew him, Mr. Say was a most pleasant and agreeable companion, a thorough student, and a man of the most unpretentious manner. Always ready to assist a friend, his stores of knowledge were freely opened to those who asked, and information was cheerfully granted to all inquirers.

ENTERTAINING VARIETIES.

—— *Spanish Enterprise.*—Peter Bayle holds that it is sufficient for the glory of a nation to have produced one superlative man in every department of human merit, and by that rule the Spaniards can hardly be charged with a want of enterprise. At the beginning of the sixteenth century, when the *autos-da-fé* of the Infallible Church had turned Southern Europe into a moral cinder-heap, a Spanish gentleman, by the name of Saavedra, and possibly a relative of the immortal Miguel, resolved to profit by the prevailing tendency of the age and graft his fortune upon the one flourishing branch of human industry. After devoting a few years to the art of counterfeiting handwritings and the selection of discreet accomplices, he suddenly appeared at Lisbon with a train of a hundred and twenty followers, and presented his credentials as a papal plenipotentiary. The spread of heresy, he informed the astonished king, called for extraordinary measures, and his Holiness had resolved to invest the Casa Santa with discretionary powers, and had sent him as a special legate with instructions to institute immediate proceedings against the prominent heretics, Moslem and Jews, of the kingdom. Some three thousand persons were summoned before the new tribunal, and, while the bewildered authorities prepared a protest against the threatened innovation, the bailiffs of the legate had arrested six hundred suspects, and forcibly collected two hundred thousand crowns as fines for contempt of court. When the relatives of the prisoners expostulated in rather emphatic terms, the legate expressed his regret at the necessity of fining them too; and, when the discontent threatened to assume the form of a general revolt, the plenipotentiary considered it his painful duty to arrest the ringleaders as abettors of heresy, and, after a formal trial and the confiscation of their property, three hundred of the malcontents were actually burned at the stake, June, 1539. The tribunal was just preparing to fine the entire city of Lisbon, when by some indiscretion of a tax-collector the imposture was discovered, but, when the citizens flew to arms, the man of God had disappeared. He was afterward captured near Seville and sent to the galleys, but, in consideration of his zeal in behalf of the holy faith, he was soon pardoned, and the Pope, moreover, confirmed the decrees of the extemporized tribunal, and, as Voltaire remarks, thus rendered sacred what before was merely human.

—— *Had the Ancients Cheap Books?*—Mr. S. E. Dawson remarks, in his lecture on copyright, that it is a very common error to suppose that the ancient world was very badly supplied with books—to transfer to the times of Greek, Roman, and Egyptian civilization the darkness and dearth of mediæval Europe. The fact is, that in those days every gentleman's house had its library and every city had its *public* library. In every wealthy household was a servant to read aloud and another to copy books. Atticus, Cicero's friend, kept a large number of slaves transcribing, and made a good deal of money by the sale of the books so manufactured. In those days a publisher or bookseller kept a staff of skilled slaves. When a book was to be published one of these read and the others wrote, and in that manner, by the means of cheap slave-labor, large editions of books were published. The literary activity of the countries round the Mediterranean was very great, and we underestimate it. Horace has preserved for us

the names of the booksellers in whose shops he used to lounge. Martial refers a shabby fellow called Lupercus (who wanted to borrow his epigrams) to his bookseller Atrectus. He tells him the shop is "opposite the forum of Cæsar, and placards are posted outside giving the names of poets," evidently as is the custom of booksellers to this day. The price of the volume—the first book of his epigrams—he says is five denarii, equivalent to three shillings and sixpence sterling. Now, this first book contains one hundred and nineteen epigrams, or over seven hundred verses. It appears elsewhere that cheaper copies were provided. Martial refers to copies well rubbed with pumice and adorned with purple. The cheaper copies could be had at half that price, but this was in the best style. So that if we compare the price with the published price in England of "Maud," or any of the original small volumes of Tennyson's poems, which were issued at five or six shillings, the Roman publisher does not seem to be much dearer than the English one.

—— The first evidence on record of an *author's right of copy* is in the case of "Paradise Lost." This transaction is usually misrepresented. The bargain was that Simmons was to pay £5 cash, £5 more when thirteen hundred copies were sold, and £5 each for the second and third editions. It took seven years to sell the first thirteen hundred copies, and in 1680 Milton's widow sold her interest for £8 more.

—— In reference to his *conversion, Sir Charles Lyell* says: "The question of the origin of species gave me much to think of, and you may well believe that it cost me a struggle to renounce my old creed. One of Darwin's reviewers put the alternative strongly by asking 'whether we are to believe that man is modified mud or modified monkey.' The mud is a great come-down from the 'archangel ruined.' Even in ten years I expect, if I live, to hear of great progress in regard to 'fossil man.'"

—— *Broderip* says that, in spite of all the dogs and cats which float down the Thames, none of their remains have been found in recent excavations in the Thames deposits.

—— *An Earthly Paradise.*—Unless the Garden of Eden was planted in the very happiest latitude, the work of the gods seems for once to have been excelled by the achievement of a mortal. Toward the end of the tenth century, Abderrahman III. the Caliph of Cordova, conceived the idea of turning a whole mountain-range into a pleasure-park. On the heights of the Sierra de Peñas he built the famous Hischam Russáva, the summer-castle, with a pedestal of massive terraces girt with lakes and artificial cascades. The western slope of the Sierra, according to Ibn Caldir, an area of forty square leagues, was planted with all the trees known to the Arabian botanists—palms, laurels, chestnuts, oaks, and mountain-firs—all ranged in groves at different altitudes, according to the higher or lower latitude of their natural habitats. Ship-loads of foreign plants were landed at the harbor of Alicante, and the transport of these botanic cargoes is said to have employed sixty caravans for more than four years. "Not Shiraz, nor Araby the Blest, had such a wealth of odoriferous shrubs," says the historian; roses trained into trees, copses of lilac and jasmine-bushes loaded the air with perfume, and the Cordova gardeners seem to have known a method for ripening winter crops without hot-houses, for the orchards of the lower slopes furnished a perennial supply of fresh fruit. On the upper levels the Caliph had his game-preserves in vast plantations of *pinabetes*, a sort of Alpine fir that formed almost impenetrable thickets, while the highest crest of the Sierra was

laid out in pleasure-walks, mountain-meadows alternating with groups of cedar-trees and rocky *altamiras* or lookout-places. Special buildings had been provided for the acclimatization, or rather localization, of whole colonies of singing-birds, which were bred in-doors for a number of years till they were tame enough to be trusted at large. From the summer-palace, at an elevation of three thousand feet over the level of the Guadalquivir, an avenue led down to the east gate of Cordova by such nice gradations that the road-bed seemed to be a perfect level, and from various directions shady trails, apparently artless, but equally well graded, wound up to the summit of the mountain-range, where the Caliph had an astronomical observatory.

Landgrave Wilhelm of Hesse-Cassel built his mountain-palace on the proceeds of six thousand of his faithful subjects, sold to England at sixty-five pounds apiece, but Abderrahman III had no need of killing his fowls to get their eggs. During the reign of the first three caliphs, Cordova was, next to Bagdad, the richest city of the world; the valley of the Guadalquivir contained thirty-six towns and eighteen hundred prosperous villages, and the contemporary historians of the West vie in extolling the beauty and luxuriance of the *Boscál*, the orchard-region that surrounded the Moorish capital with a wreath of evergreen gardens.

The Sierra de Peñas is now a naked rock, Cordova a labyrinth of ruins, infested with pigs and begging friars, and the observatory of the impious Unitarians has been turned into a shrine of San Isidro. The Boscál has become a sandy desert, but on the south side of the river there are still some good bottom-lands, and the thrice-blessed cherry-trees of the orthodox peasants continue to yield an excellent kind of brandy.

—— *Starting a New Religion.*—Professor Seeley remarks, in his new book on "Natural Religion": "It is said that the theophilanthropist Larevellère-Lepeaux once confided to Talleyrand his disappointment at the ill-success of his attempt to bring into vogue a sort of improved Christianity, a benevolent rationalism which he had invented to meet the wants of a skeptical age. 'His propaganda made no way,' he said. 'What was he to do?' he asked. The ex-bishop politely condoled with him, feared it was indeed a difficult task to found a new religion, more difficult than could be imagined—so difficult that he hardly knew what to advise. 'Still'—so he went on after a moment's reflection—'there is one plan which you might at least try: I should recommend you *to be crucified and rise again on the third day!*'"

—— *Seeley on Theological Differences.*—"Why should we be so willful as to forget that the error of monstrously overestimating doctrinal differences has been all along the plague of theology? There can be no greater mistake than to measure the real importance of a dispute by the excitement of the disputants. It has often been remarked of theological controversies that they are never conducted more bitterly than when the difference between the rival doctrines is very small. This is nearly correct, but not quite. If you want to see the true white heat of controversial passion, if you want to see men fling away the very thought of reconciliation and close in internecine conflict, you should look at controversialists who *do not differ at all*, but who have adopted different words to express the same opinion."

—— *Origin of the Arab Horse.*—Letter of the Emir Abd-el-Kader, from "The Horses of the Sahara," by General E. Dumas, 1857:

"Praise be to the one God!

"To him who remains ever the same amid the revolutions of this world:

"To our friend General Dumas.

"Peace be with you, through the mercy and blessing of Allah, on the part of the writer of this letter, on that of his mother, his children, their mother, of all the members of his family and of all his associates.

"To proceed: I have read your questions, I address to you my answers.

"You ask me for information as to the origin of the Arab horse. You are like unto a fissure in a land dried up by the sun, and which no amount of rain, however abundant, will ever be able to satisfy.

"Nevertheless, to quench, if possible, your thirst (for knowledge), I will this time go back to the very head of the fountain. The stream is there always the freshest and most pure.

"Know, then, that among us it is admitted that Allah created the horse out of the wind, as he created Adam out of mud.

"This can not be questioned. Several prophets—peace be with them!—have proclaimed what follows:

"When Allah willed to create the horse, he said to the south wind:

"'I will that a creature should proceed from thee—condense thyself!' and the wind condensed itself. Then came the angel Gabriel, and he took a handful of this matter and presented it to Allah, who formed of it a dark bay or a dark chestnut horse (*koummite*—red mingled with black), saying:

"'I have called thee horse (*frass*); I have created the Arab, and I have bestowed upon thee the color *koummite.* I have attached good fortune to the hair that falls between thy eyes. Thou shalt be the lord (*sid*) of all other animals. Men shall follow thee wheresoever thou goest. Good for pursuit as for flight, thou shalt fly without wings. Upon thy back shall riches repose, and through thy means shall wealth come.'

"Then he signed him with the sign of glory and of good fortune (*ghora*, a star in the middle of the forehead)."

—— *Carlyle on Liberty.*—Caroline Fox, in her "Memories of Old Friends," gives a vivid sketch of her last meeting with Carlyle, whose "look and most of his talk were so dreary," at Mentone. After railing "at the accursed train, with its devilish howls and yells, driving one distracted," Carlyle went on: "Oh! this cry for liberty! liberty!—which is just liberty to do the devil's work, instead of binding him with ten thousand bands—just going the way of France and America, and that sort of places. Why, it is all going down-hill as fast as it can go, and of no significance to me—I have done with it. I can take no interest in it at all, nor feel any sort of hope for the country. It is not the liberty to keep the ten commandments that they are crying out for—that used to be enough for the genuine man—but liberty to carry out their own prosperity, as they call it. And so there is no longer anything genuine to be found. It is all shoddy. Go into any shop you will, and ask for any article, and ye'll find it all one enormous lie. The country is going to perdition at a frightful pace. I give it about fifty years yet to accomplish its fall."

EDITOR'S TABLE.

WEALTHY SCIENTIFIC INVESTIGATORS.

THE appearance of Sir John Lubbock's remarkable book on "Ants and Bees" has awakened some interesting discussion as to why there are not more such authors, and why, especially, we have no representatives of the class in this country. Sir John Lubbock is a man of wealth, who could, if he pleased, "enjoy" his liberal means—that is, spend his time in dignified idleness or elegant amusement; but he finds his pleasure, on the contrary, in all kinds of hard work, and, although he takes abundant relaxation, he never wastes an hour. The "Scientific American" remarks that we have a wealthy, idle class of men, who have no need to labor with hand or head, and who are free from every care. But, impelled by fashion, hundreds of such young men are to-day scouring the Adirondacks, or shooting the rapids of the St. Lawrence, and boring themselves to death in quest of amusement, because "it is quite the thing, you know." Here is the material from which naturalists a:d independent investigators of nature ought to be recruited in this country.

To such men Sir John Lubbock has set a noble example. Something—much, indeed, is to be first of all allowed to genius, but more is to be allowed to a dominant purpose, and the unremitting assiduity which is pleasurable when there is a cultivated interest in the subject. There is an all-sided activity in this case which is quite remarkable. To begin with, Sir John Lubbock is by profession a banker, and so thoroughly a man of business as to be not only a successful money-maker, but a leading reformer of the English banking system. His important work in this direction is thus well summed up in the "Whitehall Review":

> He has made two great landmarks in the history of banking which will always be associated with his name. One of these is the bank holiday; the other, the institution of the clearing-house of country banks, by which the benefits long known in the city of London were extended to all parts of the country. All the honors that the banking world could confer upon him have been liberally bestowed. He is the president of the Institute of Bankers, with its two thousand members, and holds the peculiar and remarkable position of honorary secretary of the London Association of Bankers. He is thus the medium between the banks and the Government, and the chosen exponent of the views of bankers in relation to Government. Then, he has instituted a system of examination for bankers' clerks corresponding to the civil-service examinations. Sir John was a member of the International Coinage Committee appointed by Government, and he is the author of a great variety of papers in financial literature.

And yet all this is but the subordinate and incidental part of Sir John Lubbock's work. He is pre-eminently a scientific investigator, and it is as such that he will be chiefly known in the future. A sagacious, patient, plodding observer of minute phenomena, he is at the same time a comprehensive original thinker, and had made a world-wide reputation by his researches into prehistoric archæology before he entered upon the systematic study of the social hymenoptera, the results of which are but just published.

If, now, we press the question why there are not more such men, particularly in this country, in the ranks of science, and helping forward its work, it will be an evasion to answer that it is for lack of native capacity or the talent for such labor. We have plenty of this good mind running to waste

that might do invaluable service in the extension and diffusion of scientific knowledge. The difficulty is a lack of sufficient interest in such things to resist other solicitations. We do not begin early enough with the study of science to form deep, persistent controlling impressions. Other subjects get the start, and the loss of ground can not be subsequently recovered. Sir John Lubbock recognizes that this is a great deficiency of education in England, and he has again and again brought forward measures in Parliament for extending and rationalizing scientific study in the primary schools, so as to lay a better foundation for this mental pursuit in later life. We suffer sorely from the same neglect. Our primary-school science is not genuine; it is book-science, and awakens no feeling or enthusiasm for the study of natural things. Our rich young men, however nominally educated, have never seriously taken hold of the study of nature, and, of course, care nothing about it. Intellectual ambition, therefore—and we have plenty of that—takes other directions. Two unregulated and overwhelming passions in this country stifle the growth of science: the intense and absorbing passion for wealth, and the universal infatuation for politics. These are great national diseases, not peculiar to America, but malignant in America, and the state of mind they engender makes the systematic cultivation of scientific thought next to impossible. Hence our education issues in money-making and politics as exclusive passions, with no cherished intellectual interests to counteract and restrain them. When our early scientific education becomes more perfected and better organized, so that a strong interest in the study of nature shall be enkindled in the minds of the young, we may then hope that American young men of affluence will be more inclined to seek their gratification in some of the varied and inexhaustible pursuits of scientific knowledge. As the "Scientific American" truly remarks:

> We have men of brains, of leisure, and of means, seeking in vain for some new way of getting rid of the most valuable thing on earth—time. But they are of no use to us or to science; let them finish their days as they have begun, let them listen to a few law lectures that they do not understand, or join some political party and set up for statesmen if they have money enough to buy an office. But shall this thing go on for ever? Is it not possible to cut off, in part at least, the source of supply by turning it to other channels? Many of these young men who have now no thought beyond the morrow, no higher ambition than to color a meerschaum, were boys once—real, genuine, inquisitive boys. Then their powers of observation were capable of cultivation, then a love of nature could have been implanted in their souls, and life would have been brightened by an object, and one worthy of a life-long pursuit. When teachers cease to hold up as models those great men who, like Lincoln and Garfield, have risen from poverty and obscurity to the presidency, and point with pride to the boys who, in spite of wealth and luxury, have had the courage and perseverance to do a noble act by devoting their time, money, and talents (for some rich boys have genius as well as poor ones) to the study of nature, when teachers begin to have common sense, we may hope to see some of this valuable material rescued from its present *downward* course. Rich men are not all fools, and there are some who would take pride in a son who, although he might not be a Leidy or a Lubbock, a Darwin or a Dawson, should be able to associate on terms of scientific equality with men of that class.

BEECHER ON THEOLOGY AND EVOLUTION.

The first article in the "North American Review" for August—an excellent number—is by Henry Ward Beecher, on "The Progress of Thought in the Church." It is an independent, a powerful, and a most significant discussion, which we recommend everybody to read. We shall not attempt to make any statement of the argument, and only call attention to the large and hearty recognition of science as an agency for the purification of religion.

The progress of thought in the Church is forcibly shown to be a result of the progress of science outside the Church. The distinction between religion and theology is not new, but Mr. Beecher shows that it is wide and deep, and that religion must unload theology or sink with it. The doctrine of evolution is not only broadly accepted, but its coming is hailed as the greatest event of modern religious progress. It is destined to do what nothing else could so effectually do to sweep out of the way and into oblivion the great body of old orthodox theological dogma, by which the human mind has been perverted and enslaved for ages. We quote two or three passages, which will illustrate the positions taken by Mr. Beecher. After a brief but vivid statement of the working of the law of evolution upward through the various spheres of natural phenomena, until man and his higher development are reached, Mr. Beecher says:

At this point there is a halt. It is perhaps the most revolutionary tenet ever advanced. It will be to theology what Newton's discoveries were to the old astronomy. The repugnance that men feel at descending along such a road, and with such an ancestry, would foam and subside in a short time. It is not the retrospect, but the prospect, which gives such almost universal hesitation to the mind and imagination of mere scientific moralists. Its admission would be fatal to the theory of a plenary and verbal inspiration of the Bible still held by some. The first two chapters of Genesis have been a sword in the hands of theologues of old with which to fight the discoveries of modern astronomy. Next they were sharpened against the advent of geology. In both conflicts God prevailed and the truth was victorious. Now again, but upon a more tremendous issue, theology resists evolution. It is an honest resistance. To admit the truth of evolution is to yield up the reigning theology; it is to change the whole notion of man's origin, his nature, the problem of human life, the philosophy of morality, the theory of sin, the structure of moral government as taught in the dominant theologies of the Christian world, the fall of man in Adam, the doctrine of original sin, the nature of sin, and the method of atoning for it. The decrees of God as set forth in the confession of faith, and the machinery supposed to be set at work for man's redemption, the very nature and disposition of God—as taught in the falsely called Pauline but really Augustinian theology, popularly known as Calvinistic—must give way.

The dread of Darwinian views is sincere; yet a secret fear prevails that they may be true. But have men considered what a relief they will be from some of the most disgraceful tenets of theology? Are they content to guard and defend a terrific scheme which sullies the honor, the justice, and the love of God against a movement that will cleanse the abomination and vindicate the ways of God to man? Even if the great truth of evolution led to unbelief, it could not be so bad as that impious and malignant representation of God and his government which underlies all mediæval and most of modern theology. We shall quote from the Presbyterian Confession of Faith the account given by the Church of the origin of man and of his moral government, in the light of which the scientific account of the origin of man and the nature of sin is as health to sickness, as life to death. Instead of dreading the prevalence of the scientific doctrine, Christian men should rush toward it with open arms and exultation as a release from the hideous nightmare of ages.

The tendency of recent scientific researches and disclosures respecting the mind of man and his origin and nature will be far more pronounced upon the theories of *theology* than upon the *institutions* of religion. Christian churches are legitimate organizations for the development of religious emotion and for the application of truth to our daily life. Those churches which are organized for *devotion* will be less disturbed than academical churches which have hitherto aimed only to expound and defend a creed. But churches whose genius it is to develop religious thought, as distinguished from religious emotion, will gradually change, and the devotional element will take the place largely of the theologic, and the ethical the place of the philosophical.

When the creeds of the past era have passed away, we shall enter upon the creeds of a new era. These will differ not alone in their contents from former doctrinal standards, but they will differ in the very genius and method of construction. Our reigning creeds begin with God, with moral government, with the scheme of the universe, with the great, invisible realm beyond. These are the weakest places in a creed, because the matters they contain are least within the

reach of human reason, and because the alleged revelations from God upon them are the most scanty and uncertain. The creeds of the future will begin where the old ones ended: upon the nature of man, his condition on earth, his social duties and civil obligations, the development of his reason, his spiritual nature, its range, possibilities, education—the doctrine of the human reason, of the emotions, of the will—man as an individual, man social and collective; and, from a sound knowledge of the nature of mind, developed within the scope of our experience and observation, we shall deduce conceptions of the great mind—the God idealized from our best ascertainments—in the sphere within which our faculties were created to act with certainty of knowledge. Our creeds will ascend from the known to the unknown, which is the true law and method of acquiring knowledge. Hitherto they have expended their chief force upon that which is but dimly known.

THE DARWIN MEMORIAL.

A MOVEMENT has been started in England to get up some kind of a memorial in honor of Mr. Charles Darwin. The English Executive Committee has requested the following American gentlemen to co-operate with them in promoting the object: Asa Gray, chairman; Spencer F. Baird, James D. Dana, Charles W. Eliot, D. C. Gilman, James Hall, Joseph Le Conte, Joseph Leidy, O. C. Marsh, S. Weir Mitchell, Simon Newcomb, Charles Eliot Norton, Francis A. Walker, Theodore D. Woolsey; Alexander Agassiz, Treasurer. Subscriptions may be sent to Alexander Agassiz, Cambridge, Massachusetts, who will acknowledge the same and forward them to the Treasurer of the English Executive Committee of the Darwin Memorial.

The American committee, in their circular, without date, say that the form which the memorial is to take has not yet been decided: it will probably include an endowment for a scholarship to carry on biological research. Nothing could be more appropriate to the character of the man whose memory is to be honored than thus to link his name with the progress of knowledge in the field which he has done so much to make his own. But the "Athenæum" announces that the memorial will take the customary form of a marble statue, and that the trustees of the British Museum will be asked to place it in the large hall of the museum at South Kensington. The English subscriptions are reported as amounting to $12,500. The United Kingdom will probably be able without help to pay for a marble statue; and would it not be well for the American committee to entertain the idea of doing something independently in this country? The endowment for a biological scholarship, if abandoned in England, might well be taken up here.

LITERARY NOTICES.

A GEOGRAPHICAL READER. Compiled and arranged by JAMES JOHONNOT, author of "Country School-Houses." New York: D. Appleton & Co. Pp. 416. Price, $1.25.

THE compiler believes that it is no disadvantage for the reading-lessons given to the pupil in school to be primarily directed to some subject of thought. "If the food is also palatable as well as nutritious," the pupil becomes interested and his mind engaged with the substance of the lesson, and he will gain all the advantages that otherwise cost so much labor, without direct and conscious effort. The reading exercises should also be adapted to the condition of the pupil's mind at each period of growth, and should constitute appropriate models of style, leading in the direction of literary excellence. Hence is suggested the propriety of introducing lessons bearing on some topic of study which the pupil is pursuing at the same time. Text-books give, necessarily, the bare outlines. The reading-books might help to fill up the outlines with details, giving fuller descriptions of the most interesting features, and the stories which the children love so well. When these supplementary elements are chosen from classic authors, we have what we might call an

ideal reading-book on the subject in hand. The present work is an attempt to apply these principles to geographical topics. The order of the topics is the same as is found in any well-arranged text-book on the subject; and the articles are from writers of acknowledged excellence. We have in twenty chapters selections on the several varieties of natural features and scenery, on the surface of the earth, volcanic and meteorological phenomena, natural curiosities, wild animals, national characteristics, peculiar customs, regions, and people, cities, ancient works and ruins, and modern works, etc., given in the form of essays, popular descriptions, narratives of travel, scientific accounts, and poems, by a list of writers embracing the names of European and American authors who have become distinguished in various fields of literature and science.

The Science of Ethics. By Leslie Stephen. New York: G. P. Putnam's Sons. Pp. 462. Price, $4.

The author of this book has his own views of morality, and, although he does not profess to have made any great revolution in the science, he has still made a book which is worthy of careful consideration. It is an unusually spirited and attractive volume on what is commonly regarded as the dullest of subjects.

Mr. Stephen began as an orthodox utilitarian in morals, and avows that the Gamaliel at whose feet he sat was John Stuart Mill. This, however, he regards as an immature proceeding, in which he merely joined other thoughtful lads in deferring to one whose authority was decisive. At a later period his mind was much stirred by the appearance of Darwin's "Origin of Species." He acknowledges great indebtedness to Darwin's writings, but so far as ethical problems are concerned he came at length to think that the Darwinian resources were unsatisfactory, and that a deeper view was necessary—this conviction being due to the influence of Herbert Spencer's writings. After an historical examination of the English moralists of the eighteenth century, Mr. Stephen read the "Methods of Ethics," by Henry Sedgwick, and, although admiring the work, he found himself differing from it at so many points that he resolved to publish systematically upon the subject himself. Mr. Stephen regards the relation of evolution to ethics as its critical point, while Mr. Sedgwick belittled it, and thus left a great deal to be done in clearing up the inquiry.

Of his attempt Mr. Stephen says: "At times I have been startled at my own impudence when virtually sitting in judgment upon all the deepest and acutest thinkers since the days of Plato. But I easily comfort myself by remembering that the evolution of thought is furthered by the efforts of the weak as well as of the strongest; and that, if giants have laid the foundations, even dwarfs may add something to the superstructure of the great edifice of science. So far as my reading has gone, I have found only two kinds of speculation which are absolutely useless—that of the hopelessly stupid and that of the hopelessly insincere. The fool who does not know his own folly may be doing nothing, and the philosopher who is trying to darken knowledge may be doing worse than nothing, but every sincere attempt to grapple with real difficulties made by a man not utterly incompetent has its value. I claim to come within that description, though I claim nothing more. And I have the satisfaction—not a very edifying one, it may be said, for a professed moralist—to reflect that if my book does no good to anybody else, it has provided me with an innocent occupation for a longer time than I quite like to remember; while I hope that there is nothing in it—if I may apply to myself what a discerning critic has said of Dr. Watts's sermons—"calculated to call a blush to the cheek of modesty."

Modern Applications of Electricity. By E. Hospitalier. Translated and enlarged by Julius Maier. New York: D. Appleton & Co. 1882. Pp. 456. Price, $4.50.

In the present state of public interest in the applications of electricity, any author who succeeds in presenting the subject in a popular manner may expect a favorable reception, and we doubt not such will be accorded to this latest addition to works of this character. M. Hospitalier's exposition is clear and concise, and popular enough in form to be interesting and intelligible to a wide circle of readers. The work consists

of four principal parts, in the first of which the author considers the sources of electricity—hydro- and thermo-electric batteries and machines—and also various apparatus for transforming currents, under which heading he places accumulators or secondary batteries. The second part is devoted to electric lamps—regulators, candles, and those producing light by incandescence. In the third division the subject of telephones and microphones is taken up, and all the later forms of these pieces of apparatus are described. In the fourth and final part there are considered various applications of electricity, such as devices for indicating fire-damp in coal-mines, fire-alarms, etc., the electrical transmissional power, electro-motors, and electric distribution.

While the book will be found in many respects an excellent popular *résumé* of the subject, it is not without defects, and lacks the completeness which a work of this character should at the present time possess. The daily as well as the technical press has familiarized most persons interested in the subject with the various types of lamps which have so far been developed, and the questions of interest now are mainly those of cost and the conditions upon which electric lighting in general depends. Much of the description of different forms of lamps of the same class might, therefore, have been dispensed with—such, for instance, as the various forms of candles and the lamps of imperfect contact, neither of which promise to have much of a future before them—and been given with advantage to incandescent lamps employing a carbon filament. The treatment of this class of lamps is, to say the least, meager, and that of the workers in this field far from satisfactory. One would hardly get a correct idea of the relation of Mr. Edison's work to the present successful results by the author's presentation of it. The treatment of the problem of distribution is hardly as full and complete as might be desired, or the work of M. Marcel Deprez in this direction as clear and as full as it should be. The work on the whole is, however, a very readable one, and will give those unacquainted with the recent advances in the industrial applications of electricity a fairly good idea of what has been so far accomplished.

An Etymological Dictionary of the English Language. By the Rev. Walter W. Skeat, M. A., of the University of Cambridge. New York: Macmillan & Co. Pp. 799. Price, $2.50.

This work may be regarded as in certain senses a pioneer in the field of literature to which it relates. The aim of the author has been to furnish students with materials for a more scientific study of English etymology than is commonly to be found in previous works on the subject. The older dictionaries were rich in quotations illustrative of the words they defined, but their etymologies were defective and of the crudest kind, being in most cases thoroughly unscientific guess-work, and most likely wrong. In many instances, Mr. Skeat says, he has found evidence that the dictionary-makers manufactured words for the express purpose of deriving others from them. The earlier editions of Webster's "Dictionary" gave the corresponding words and the one under consideration from a great number of languages, without any discrimination based upon the possibility of their having or not having a real relation with the English word. Such comparison was, perhaps, interesting as a curiosity, but was confusing to etymological students, and could give no clew to the derivation of the word. Better work has been done in the later editions of Webster, in which Dr. Mahn's etymologies deserve and receive commendation; but the plan of the work, says Mr. Skeat, "does not allow of much explanation of a purely philological character." In preparing his work the author has been guided by certain canons, a few of which, such as commend themselves to the general reader, are: Before attempting an etymology, ascertain the earliest form and use of the word, and observe chronology, observe history and geography, observe phonetic laws. The whole of a word, and not a portion only, ought to be reasonably accounted for; mere resemblance of form, and apparent connection in sense between languages which have different phonetic laws, or no necessary connection, are commonly a delusion, and are not to be regarded; and it is useless to offer an explanation of an English word which will not also explain all the cognate forms. The attempt is made to give the exact history of

each word, and, to make its pedigree complete, it is traced through all the ascertained successive changes, in their order, which it has passed through in the several languages through which it has come down, as if by descent, to us. Thus, in the case of the word "canopy," it is shown, by the brief, clear notation which is adopted throughout the book, that the word is derived in English from the French, the French from the Italian, that from the Latin, and that from the Greek; and if the ultimate Aryan root can be deduced, that is indicated. This, Mr. Skeat believes, is the first attempt of this kind that has been made, except partially. Another notation, equally simple and plain, shows cognate forms and distinguishes them from descending forms. Many of the articles are quite full histories, and all are rich in suggestions to the thoughtful student. Mr. Skeat frankly confesses to a number of short-comings. The remark to be made about them is not so much that they exist, as that the author should take the pains to call attention to them. On review they appear generally to be such as must inevitably beset the student who has to undertake so large a subject alone, or such as every one who attempts to advance into so extensive a field, that has been heretofore so little or so unskillfully cultivated, must expect to be liable to.

Our Merchant Marine: How it Rose, Increased, became Great, Declined, and Decayed; with an Inquiry into the Conditions essential to its Resuscitation and Future Prosperity. By David A. Wells. New York: G. P. Putnam's Sons. Pp. 219.

Professor Wells undertakes a diagnosis of the disease with which our merchant marine is afflicted, through the operation of which, from having once been our pride and boast, it has fallen in the course of a quarter of a century into a contemptible insignificance; or, to illustrate the subject by figures, from carrying in 1855 75·5 per cent of the imports and exports of the country, by steady diminutions to carrying only 16·2 per cent of them in 1881. The most direct cause of decay is found in our navigation laws, under which the privileges essential to the prosperity of an American merchant marine are confined to American-built vessels, and denied to all ships bought abroad. In connection with this cause others are operating which bear with peculiar hardship on American vessels and American ship-building enterprises, such as high duties on imported materials used in ship-building, and various local burdens, in the imposition of which a positive discrimination appears to be made against American vessels. Back of these causes and under some of them lies the fundamental cause, in the protective system, some of whose most positive advocates have avowed the belief that the policy of the country is to discourage commerce, and the provisions of which have been adjusted, whether designedly or not, in consistency with this belief. No one measure, the author concludes, "will arrest the decay of American shipping, bring back prosperity to our ocean carrying-trade, or revive the industry of ship-building in this country. The field of reform to be entered upon is a very large one; the number of details which are to be attended to are numerous; but reform, nevertheless, is both possible and practicable if the American people desire and will it." He then mentions the most essential measures of reform, the nature of which is indicated generally by the references we have made to the evils that demand a remedy.

Science Ladders—No. I. Forms of Land and Water. Pp. 67. No. III. Vegetable Life. Pp. 78. By N. D'Anvers, author of "Heroes of North African Discovery," etc. Both illustrated. New York: G. P. Putnam's Sons. Price, 50 cents each.

The author states that his design in planning the series of which these works are a part has been to teach the great laws of Nature in language simple enough for every child to read, and to awaken the powers of observation and reasoning by means of purely elementary descriptions. "The Forms of Land and Water" gives descriptions of the earth and its general features and phenomena. "Vegetable Life" is intended to teach the laws of the life and growth of plants and to serve as an introduction to elementary botany. The effort has not been a happy one. The style is childish instead of simple, and is calculated to lead to inexactness and confusion; pains are taken to give a knowledge

of scientific terms and their definitions which should rather have been applied to the communication in really plain language of the facts which the words indicate. The matter is above the comprehension of the kind of children for whom the style seems to be intended, and the style is not adapted to the tastes of larger ones. The illustrations are excellent.

The Gospel of Law. A Series of Discourses upon Fundamental Church Doctrines. By S. J. Stewart. Boston: George H. Ellis. Pp. 326. Price, $1.25.

The author is pastor of the Independent Congregational Society of Bangor, Maine. The substance of the volume was originally delivered as a series of regular Sunday discourses before his people. The principal motive of the book is stated to be "to apply the facts of science to inherited doctrines, and then to give a positive basis of belief and conduct in consistency with these facts, to interpret the results of the best authorities, and to bring them into a practical form and conclusion." The author apparently belongs to the advanced rank of "free religious" thinkers. He denies the supernatural character and authority of the "Church of tradition," and of its gospel, and would substitute for the latter a "gospel of law," the fundamental principle of which is that every effect is the natural product of some natural cause.

Manual of Object-Teaching, with Illustrative Lessons in Methods and the Science of Education. By N. A. Calkins. New York: Harper & Brothers. Pp. 469. Price, $1.25.

The author of this book is and has long been one of the Superintendents of the Public Schools of the city of New York, and the supervision of object-lesson studies falls within his department. His writings upon that subject have, therefore, a broad basis of experience, involving the trial of methods and the improvement and extension of the objective system. Mr. Calkins published, some years ago, the "Primary Object Lessons," which has been well received and generally adopted. The new work now issued—the "Manual"—extends over a broader field, and embraces subjects and methods for more advanced teaching than those presented in the author's earlier work. It is, therefore, not a substitute for that book, nor a revision of it, but an entirely new treatise, with a great variety of appropriate topics, materials, and suggestions to aid teachers in oral instruction. In this line Mr. Calkins's books are authorities at the present time.

Hints and Remedies for the Treatment of Common Accidents and Diseases; and Rules of Simple Hygiene. In Two Parts, complete. Compiled by Dawson W. Turner, D. C. L., late Head-master of the Royal Institution School, Liverpool; sometime Student of Westminster Hospital and of Charing Cross Hospital. Revised, corrected, and enlarged by Twelve Eminent Medical Men belonging to Different Hospitals in London, and by one Right Reverend Bishop of the Established Church, formerly Surgeon to one of the London Hospitals, and F. R. C. S. With numerous Additions, from the eighth English edition. New York: Macmillan & Co. Pp. 106. Price, 50 cents.

A book so well backed and braced by authorities as this may seem to need no commendation from us; but a careful examination of it has shown that it is a most practical, judicious, carefully considered digest of hygienic rules and hints about health which is well calculated to be useful to everybody.

Good Cheer. A Monthly Paper devoted to Home Science and the Interests of the Family generally. Greenfield, Massachusetts: Good Cheer Publishing Company. Pp. 16. 50 cents a year.

This new venture in the literary field is bright, varied, and spicy, and the best newspaper bargain for the family now a-going at fifty cents. There is a practical turn about it that is promising, and its scientific side will probably improve with time. The mechanical style of its title, however, seems open to criticism. An artist has been let loose upon it, and the consequence is obscurity. A title, of all things, should be clear, and not so buried up in artistic beauty that we have to spend time digging out what it means. Give us clear, plain, sharp lettering that tells its whole story at the first glance, and let the artist revel in the advertisements.

Copyright in Books: An Inquiry into the Origin and an Account of the Present State of the Law in Canada. A Lecture delivered before the Law School of Bishop's College at Sherbrooke. By S. E. Dawson. Montreal: Dawson Brothers. Pp. 40, with Appendix.

This is a very instructive address, by one who is well up in copyright erudition. The account of the origin of copyright is particularly excellent, while the exposition of the present state of copyright law and practice in Canada, and how the policy of the home Government has borne upon the British Provinces, will be of interest to all who are concerned about this subject.

It is curious to note how the first institution which was invested with the control of publication in England, by which authors' rights in their books were protected, was established as a means of maintaining religious orthodoxy. The Stationers' Company, which, like all the other ancient trading guilds, had existed from the middle ages, received a chartered extension of its powers "to search out and destroy" books printed in contravention of the company's monopoly, "or against faith and sound doctrine." On this point Mr. Dawson observes:

> No record exists of authors' rights having been claimed for more than one hundred years after the invention of printing. There was no restriction in printing books, any more than there had been in copying manuscript books. Every printer printed what he chose, without let or hindrance from any person. At the end of that period, however, the enormous power of the press became manifest. The stir of thought which produced the Reformation had been caused, and was kept up, by the art of printing; and when Philip and Mary came to the throne of England they set themselves to stem the tide of innovation. For that purpose they incorporated the Stationers' Company by royal charter for licensing and regulating the printing and sale of books, and they vested in this company a monopoly of multiplying copies. The preamble to the charter sets forth its object. It reads:
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> "Know ye, that we, considering and manifestly perceiving that several seditious heretical books, both in verse and prose, are daily published, stamped and printed, by divers scandalous, schismatical, and heretical persons, not only exciting our subjects and liege-men to sedition and disobedience against us, our crown, and dignity, but also to the renewal and propagating very great and detestable heresies against the faith and sound Catholic doctrine of Holy Mother the Church, and being willing to provide a remedy in this case," etc.

A Practical Treatise on Diseases of the Skin. By Louis A. Duhring, M. D., Professor of Diseases of the Skin in the Hospital of the University of Pennsylvania; Dermatologist to the Philadelphia Hospital; Consulting Physician to the Dispensary for Skin Diseases, Philadelphia; Author of the "Atlas of Skin Diseases," etc. Third edition, revised and enlarged. J. B. Lippincott & Co. Pp. 684. Price, $6.

A third edition of this excellent work having been called for, the approbation of the profession must be taken as determining it to rank as one of the standards of medical literature. The plan of the work is that of a practical treatise, which, while making no pretension to being exhaustive, yet comprises sufficient to afford a clear insight into the elements of dermatology, and a knowledge of the important facts in connection with each disease treated of. The progress of dermatological science, in both its physiological and pathological aspects, has been very rapid in recent years, which makes indispensable the frequent revision of works on skin-diseases. The second edition of this work was accordingly carefully rewritten and much extended. The third edition has also been critically revised, and brought sharply up to date. The chapter on the anatomy and physiology of the skin has been rewritten and elaborated, this change being demanded by the recent studies in microscopic anatomy. The book as a whole has also been considerably enlarged. Numerous additions in the way of cases illustrating rare forms of disease, new and important observations, personal experience, and therapeutical information, will be found upon almost every page.

Errors in the Use of English. By the late William B. Hodgson, LL. D., Fellow of the College of Preceptors and Professor of Political Economy in the University of Edinburgh. American revised edition. Pp. 246. Price, $1.50.

There are few things to be done in this world that can not be overdone, and among the things that can be studied out of all proportion to their importance are the exquisite niceties and transcendental refinements of language. The danger of excess here is, however, because a high standard of excellence is justly demanded. Dr. Hodg-

son's book recognizes the need of adopting such a standard in the study of English; and, what is more important, it adopts the right plan to secure this as a practicable thing. The author's principle is that example is better than precept, and instead of working up a lot of rules to be learned and applied, his book consists of examples of the erroneous use of language, from many and reputable sources. He points out errors, faults, and blunders in composition, but he shows that all writers—even the best—have their lapses. The book is very interesting and teaches in the best manner by concrete illustrations of the errors to be avoided. Dr. Hodgson was a man of fine literary taste, very widely read, and methodical in his observations; he has accordingly enriched his book with a host of examples of incorrect language, commonly overlooked, which will be of invaluable service to the critical students of English.

Mrs. Hodgson appends the following note to the preface: "The materials of this little volume were selected by my husband from his notes of many years' extensive and varied reading, and they were arranged for publication in their present form before his death. In now conducting the book through the press I have had the assistance of kind friends to whom his memory is dear. But, deprived of his own revisal, there may be errors and imperfections that have escaped our notice, and for such I must ask the reader's considerate indulgence."

This incompleteness or lack of finish in the volume on the part of the author made desirable a critical revision of the American edition; this has been done by Mr. Francis A. Teall, with excellent judgment and discrimination.

American College Directory and Universal Catalogue. Published by C. H. Evans & Co., Managers of the American Teachers' Bureau, St. Louis. Pp. 168. Price, $1.

The Directory contains descriptions of more than 3,600 institutions of every kind, from the Kindergarten to the university, throughout the United States, with lists of State, city, and county school-officers and educational periodicals; a synopsis of the public-school system; a sketch of education in foreign countries; and much other valuable matter. The present volume is the fourth in annual series; it has been prepared under such advantages as it is believed make it more full and accurate than its predecessors, and is enriched with four new departments—those of "College Y. M. C. A.," city superintendents, county superintendents, and the foreign department, which embraces the comparative statistics of elementary education in fifty different countries.

What is Bright's Disease? Its Curability. By Seth Pancoast, M. D. With Illustrations. Philadelphia: Published by the author, 917 Arch Street. Pp. 152. Price, $1.

The author maintains that the view of Bright's disease as a local disease and its treatment under that view are mistaken. He advances the idea that the primary cause of the disease lies in the organic nervous system, which controls the nutrition and growth of the entire organism, as well as the elimination of the products of disintegration; that it may exist for many months, if not years, before albumen is detected in the urine; and that then other organs are involved, not from sympathy with the kidneys, but from innervation of the nervo-vital energy. He has found it curable when treated in the light of his theory, provided the disorganization has not proceeded too far.

Kant's Critique of Pure Reason: A Critical Exposition. By George S. Morris, Ph. D., Professor in the University of Michigan. Chicago: S. C. Griggs & Co. Pp. 272. Price, $1.25.

The present volume is the first of a series of "German Philosophical Classics for English Readers and Students," to be issued by the publishers under the general editorial supervision of Professor Morris, each volume of which will be devoted to the critical exposition of some one masterpiece of German philosophical thought. The editors will seek in each case to furnish a clear and attractive statement of the special substance and purport of the original author's argument, with interpretations and elucidations in the light of the historic and acknowledged results of philosophic inquiry, and independent estimates of the merits and deficiencies of his work, and they will have especial ref-

erence to its relations with British speculation. Besides the general editor, several eminent scholars and teachers have been invited to prepare particular volumes of the series. The prominence of Kant among modern philosophers and the general merits of his work make it eminently fitting that he be given the first place in the series. His thoughts certainly deserve and need to be set forth in a shape in which they may be accessible and intelligible to the average of thinking readers. Professor Morris has undertaken this task in the face, he acknowledges, of considerable difficulties, among which are that "Kant's work marks and conspicuously illustrates a stadium of transition in the history of modern thought," that "it is far more eminently the story of a process of inquiry and demonstration than a didactic exposition of finished results," and that "Kant's intellectual attitude, in some of its most essential aspects, remains, to the end, thoroughly confused."

The Psychology of the Salem Witchcraft of 1692, and its Practical Application to our own Time. By George M. Beard, A. M., M. D. New York: G. P. Putnam's Sons. Pp. 112. Price, $1.

Dr. Beard's essay has less immediate bearing on the Salem witchcraft than on the case of a murderer who was recently executed at Washington. The witchcraft excitement of 1692 is used as a pivot on which to hang a plea in behalf of the murderer. The people of New England were under a delusion when they tried and hung the Salem witches; so, it is argued, we have been under a terrible delusion in trying and hanging the murderer of our President.

Geological Sketches at Home and Abroad. By Archibald Geikie, LL. D., F. R. S. New York: Macmillan & Co. Pp. 335. Price, $1.75.

Professor Geikie is a very sound geologist, but we are inclined to think he is more at home in the work of exploration than in that of essay-writing. The papers of this collection are all good and solid, and will interest those already instructed in its line of topics, but they have not a large share of the quality which will attract general readers.

Unscientific Treatment of the Insane.—In his paper on "Insanity in its Relations to the Medical Profession and Lunatic Hospitals," Dr. Nathan Allen points out several serious defects in the management of our hospitals for the insane. The first of his objections is to the separation of the experts from the medical profession and the placing of the study of insanity and the care of the insane so exclusively in their hands. A second fault is in the erection of so large and expensive buildings, by which a multitude of difficulties, avoidable in the multiplication of smaller establishments, are encountered. The system itself, moreover, is wrong, in that it aggregates such large masses of diseased persons; and it violates sanitary laws by bringing the diseased in contact with each other, to infect each other with the most infectious of all disorders—those of the mind. A fifth objection is that the magnitude of the congregations precludes the employment of the highest order of sanitary agencies for the health and improvement of the patients. Finally, it is objected that the present system tends directly to confine the knowledge and treatment of insanity to a few individuals. Add to this that no plans are devised or means employed to prevent insanity, and we have abundant reason, Dr. Allen thinks, to revise our system.

PUBLICATIONS RECEIVED.

The Prehistoric Architecture of America. By Stephen D. Peet. Reprint from the "American Antiquarian." Pp. 16.

The Prevention of Yellow Fever. By Professor Stanford E. Chaille, M. D. New Orleans: L. Graham & Son, Printers. 1882. Pp. 22.

The Culture and Management of our Forests. By H. W. S. Cleveland. Springfield, Ill.: H. W. Rokker, printer. 1882. Pp. 16.

Tenth Census of the United States. Forestry Bulletins Nos. 1 to 16. With Special Reference to the Lumber Industry. December, 1881.

The Fifty-eighth Annual Report of the Officers of the Retreat for the Insane of Hartford, Connecticut. Hartford. 1882. Pp. 35.

Consumption: Its Causes, Prevention, and Hygienic Management. By W. H. Smith, M. D., Ph. D. St. Clair, Michigan. Pp. 11.

Report on Surgery. By W. O. Roberts, M. D. Reprint from the "American Practitioner," Louisville. 1882. Pp. 16.

Socialism and Christianity. By H. Cheroung. Printed by the Author. New York. 1882. Pp. 42. 15 cents.

Account of Field Experiments with Fertilizers. By Professor W. O. Atwater. From the Report of the Connecticut Board of Agriculture. 1881. Pp. 25.

Coöperative Experimenting as a Means of studying the Effects of Fertilizers and the Feeding Capacities of Plants. By Professor W. O. Atwater. Washington: Government Printing-Office. 1882. Pp. 33.

Anlagen von Hausentwässerungen nach Studien americanischer Verhältnisse. [Elements of House-Drainage, after Studies of American Arrangements.] Mitgetheilt von W. Paul Gerhart, Civil Engineer, Newport, R. I. Berlin, 1880: Polytechnische Buchhandlung, A. Seydel. Pp. 38, with Five Plates.

House-Drainage and Sanitary Plumbing. Providence, R. I., 1882, pp. 104; and Diagram of Sewer Calculations, Newport, R. I., 1881, pp. 7. By William Paul Gerhart, Civil and Sanitary Engineer.

An Organ-Pipe Sonomoter. By W. Le Conte Stevens. Reprint from the "Journal of the Franklin Institute," July, 1882. Pp. 5.

Physiological Perspective. By W. Le Conte Stevens. From the "Philosophical Magazine," May, 1882. Pp. 17.

Two Cases of Hemi-Achromatopsia. By Henry D. Noyes, M. D. New York. 1882. Pp. 12.

Second Annual Report of the Astronomer in charge of the Horological and Thermometric Bureaus in the Observatory of Yale College. By Leonard Waldo. New Haven. 1882. Pp. 16.

Dangerous Illuminating Oils. By J. K. Macomber. State Agricultural College. Ames, Iowa. Pp. 6.

Plastic Splints in Surgery. By Samuel N. Nelson, M. D., Brooklyn, N. Y. 1882. Pp. 18.

Pro and Con of Spelling Reform. By Professor E. O. Vaile. New York: Burney & Co. 1882. Pp. 20.

Double Irrigation and Drainage Tubes; Uterine Dilatation by Elastic Force; The Cure of Hernia by the Antiseptic Use of Animal Ligature. By Henry O. Marcy, M. D. London: J. W. Kolckmann. 1881. Pp. 12.

First Annual Report of the Committee on the American School of Classical Studies at Athens. Pp. 13.

Professional Papers of the Signal Service: No. 1, Solar Eclipse of July, 1878, by Cleveland Abbe, 1881, pp. 186; No. 2, Isothermal Lines of the United States, 1871–1880, by Lieutenant A. W. Gruely. 1881; No. 3 Chronological List of Auroras observed from 1870 to 1879, by Lieutenant A. W. Gruely, 1881, pp. 76; No. 5, Information relative to the Construction and Maintenance of Time-Balls, 1881, pp. 71; No. 6, The Reduction of Air-Pressure to Sea-Level at Elevated Stations west of the Mississippi River, by Henry A. Hazen, A. M., 1882, pp. 42. Washington: Government Printing-Office.

Tenth Census of the United States; Statistics of Power and Machinery employed in Manufactures, by Professor W. P. Trowbridge: Water-Power of the Southern Atlantic Water-Shed of the United States, by George F. Swan, S. B. Washington: Government Printing-Office. 1881.

Action of Free Molecules on Radiant Heat, and its Conversion thereby into Sound. By John Tyndall, F.R.S. From the Philosophical Transactions of the Royal Society, Part I. 1882. Pp. 64.

Bird-Bolts: Shots on the Wing. By Francis Tiffany. Boston: George H. Ellis. 1882. Pp. 180.

Eliane. By Mme. Augustus Craven. From the French by Lady Georgiana Fullerton. New York: William S. Gottsberger. 1882. Pp. 340. 90 cents.

Studies in Science and Religion. By G. Frederick Wright. Andover: Warren F. Draper. 1882. Pp. 390.

Annual Report of the Chief Signal Officer to the Secretary of War for the Year 1879. Washington: Government Printing-Office. 1880. Pp. 782.

Practical Microscopy. By George E. Davis, F. R. M. S., etc. Second edition. London: David Bogue. 1882. Pp. 335. Illustrated.

POPULAR MISCELLANY.

Experiments in Ensilage.—Professor W. A. Henry, of the Experimental Farm of the University of Wisconsin, has published a report of an experiment in ensilage that was made last year under his direction. A pit was made, thirty feet long by fifteen wide and fifteen deep, with thick stone walls, at a cost of $413.12, and was filled to near the top with a crop of fodder-corn that had been raised and cut up for the purpose, weighing 150,222 pounds, and at the top with second-crop clover just as it came from the field, all under the inspection of many visitors who had been invited to witness the process. "The comments," says Professor Henry, "were as varied as the visitors. As the weather was very warm the ensilage heated rapidly, and when the visitor would run his hand down into the mass of damp-cut fodder, and find it so hot as to be uncomfortable, there would sometimes come a shake of the head and prediction of failure of some sort: 'It will burn the barn up'; 'May keep below, but will not on top'; 'Think it will be all right above where it can get some air, but below it will make a nice manure-heap.'" The silo was loaded down with an unusual weight of stones, in order to bring the more pressure to bear upon the long and matted clover-stalks; for the efficacy of the operation depends upon the prevention of heating by cutting off the access of fresh air. After the pit was closed, but little evidence of the change within was seen, only occasionally a just discernible but not at all marked odor. When the silo was opened, November 29th, the clover was partly decayed for about a half-inch down, and moldy for two or three inches below and around the sides of the pit. This was thrown out to be put on the manure-heap. The cows were a little shy of eating the ensilage at first, but after four or five feeds all ate it as naturally as they would hay.

Then the clover that had been thrown away attracted their attention, and they ate greedily even of that which was musty. A small extemporized silo was tentatively made, in the natural ground where it was well drained, without walling, and was filled with green clover. The ensilage came out in perfect condition and entirely palatable. The result of the last experiment shows how persons living where the subsoil is very compact might make a silo with either very light walls or with none at all.

How Oölite may be formed.—Mr. F. W. Putnam, in giving an account of a visit he made some months ago to the Mammoth Cave, remarks that in one of the newly discovered chambers he noticed that many fragments of stalactites and small pieces from the walls of the cave, which had fallen into a little pool, were worn round and smooth by constant attrition, occasioned by the dropping of water from the high ceiling of the chamber. Should the water cease to drip in this place, as it probably will, and that in the pool evaporate, leaving the lime to crystallize about these small pebbles, a conglomerate would be formed which would have some resemblance to oölitic limestone, pebbles of which occurred in the pool, probably derived from fragments detached from the walls of the chamber. Calling attention to the formation of "cave pearls," which he had found in Grand Avenue Cave some years ago, he remarked that should such a mass of small pearl-like lime-concretions as were found in the last-named cave ever be cemented together, the resemblance to oölite would be very marked. While he did not wish to be understood as stating that the oölitic limestone was formed in this way, he could not help thinking that a rock of similar appearance might be locally so produced under the conditions he had observed.

Lead in Food and the Industrial Arts.—M. Armand Gautier has recently published a memorandum on the dangers arising from the use of lead in food-vessels and in various arts, and on the means of counteracting them. He shows that lead may be detected in preserved vegetables, fish, lobsters, meats, in drinking-water, and water artificially charged with carbonic acid, in acid foods and drinks preserved in glass vessels, in tin dishes, in the coverings of our walls and furniture, in the leather of our boots, in our dishes, and in our glazed table-cloths. He gives a simple and practical test for the presence of lead in solder or tinned or solid metal, and for estimating the proportion of the poison that may be there. It consists in turning on two drops of acetic acid upon the surface of the metallic object, allowing it to evaporate in the air, then touching with a solution of chromate of potash, letting dry, and washing with water. The yellow chromate of lead, thus obtained, adheres to the metal, and does not change color for several days, so that the spot can be kept in evidence. When a tin thus treated shows a yellow spot it should be rejected; if it is used in a food-can the contents should be regarded as suspicious, even if the soldering has all been done on the outside, as the latest regulations require. The general use of food preparations done up in metallic boxes that are soldered with an alloy of lead necessarily results in the introduction of a little lead into the economy, and, according to M. Gautier, the proportions of lead thus absorbed, generally very weak with vegetables, are much stronger in foods rich with fats, and especially in fish preserved in oil; the oils that surround the fish are still more strongly charged with it; and preserved meats contain it in widely varying proportions. The lead appears to exist in vegetables in the shape of an albuminate soluble in the acids of the stomach, in fat-substances as an oleate and a palminate dissolved in the fats, and absorbable with them when they undergo emulsion in the digestive tube. The use of lead in a multitude of arts and trades, too numerous to be named here, leads to more perceptible and extensive poisoning than the minute quantities of the metal that reach us through our foods and food-vessels, the importance of which is indicated by the admission of an average number of seven hundred workmen suffering from it to the hospitals of Paris every year. The compounds of lead with which these workmen come in contact are absorbed by the skin, the mouth, the nostrils, and in breathing. To workmen exposed to such

danger M. Gautier advises avoidance of everything that can raise a dust of leaden compounds, of all unnecessary direct contact with lead and its preparations, scrupulous care for the cleanliness of person, clothing, tools, face, and mouth, and observance of general hygienic rules and temperance.

Disadvantages and Advantages of Bacteria.—In a paper on "Bacteria in Healthy Individuals," Surgeon George M. Sternberg, of the United States Army, considers the question, which many have been ready to ask, If bacteria are such terrible things, how is it possible that we can exist upon the earth, surrounded and infested as we are by them? "Certainly," says Surgeon Sternberg, "there would be an end to all animal life, or rather there would never have been a beginning, if living animals had no greater resisting power to the attacks of these parasites, which by numbers and rapid development make up for their minute size, than has dead animal matter." The obvious answer to the question, that living animals have the required superior resisting power, is supported by Pasteur's researches, which show that it depends very much upon certain well-defined circumstances whether the same bacterium is a harmless parasite and commensal of man and animals, or an active agent promoting disease and decay. "Nature," says Dr. Sternberg, "has placed in the living tissues of animals a resisting power against the encroachments of bacterial organisms invading and surrounding them, which is sufficient for ordinary emergencies. But when the vital resistance of the tissues is reduced, on the one hand, by wasting sickness, profuse discharges, etc., or, on the other hand, the vital activity of the invading parasitic organism is increased, the balance of power rests with the infinitesimal but potent micrococcus. . . . Experiment has demonstrated that, by some unknown mechanism, the ordinary bacteria of putrefaction, and, under certain circumstances, even pathogenic organisms, may be introduced directly into the circulation without the production of evil consequences, and that after a short interval microscopical examination does not reveal their presence in the blood." There is compensation for the damage wrought by bacteria, which is described by Dr. Sternberg with some exaggeration, and hardly sufficient consideration of the power of the normal chemical forces of nature, in these words: "On the other hand, but for the power of these little giants to pull to pieces dead animal matter, we should have dead bodies piled up on all sides of us in as perfect a state of preservation as canned lobster or pickled tongue, and there being no return to the soil of the materials composing these bodies, our sequoias and oaks would dwindle to lichens and mosses, and finally all vegetation would disappear, and the surface of the earth would be a barren and desolate wilderness, covered only with the inanimate forms of successive generations of plants and animals."

Variable Stars.—Professor A. Ritter attempts, in his recent work on the "Application of the Mechanical Theory of Heat to Cosmological Problems," to explain the origin and nature of variable stars by supposing that, stable as they appear to our limited vision, the planetary systems are subject to ceaseless recurring changes, in the course of which they go through all the phases of cosmical evolution. The speed of the revolutions of the several members of the systems being constantly retarded by the resistance of the ether, they eventually yield to the attraction of the central body and fall into it. The concussion generates heat enough to resolve the whole mass into a vapor or gas which diffuses itself through space till its surplus heat is so dissipated that the attractive force is able to overcome its power of expansion, when the vapors begin to contract, and consequently to develop heat anew. The internal heat of the contracting body at last becomes strong enough to overcome the force of gravitation, and a new expansion begins. The gaseous sphere is thus subjected to a movement of rhythmical pulsation, the temperature increasing with the contractions and diminishing with the expansions, and will appear from a distance, if the variations in temperature reach a certain degree, alternately bright and dark, or as a variable star. The duration of the pulsations will vary according to the size of the body, and the period will bear a certain relation to its density; so that we may deduce one of the

elements from the others. When our sun filled the orbit of Neptune, it probably appeared to the inhabitants of other worlds as a variable star, with a period of three hundred and forty years. The appearance of change is confined to the youth of a star; for when it has become so dense that the variations bear only a minute ratio to the absolute brightness of the body, they cease to be noticed. The gradual and seemingly permanent disappearance of stars that have suddenly shone out is accounted for by supposing their periods of change to be immensely long. As hundreds of years must have elapsed after our sun first shone out before the gaseous particles began to move back toward the center, so, if the concussion is vastly more violent than that which produced the sun, thousands of years must pass before a concentration can begin. The origin of the apparently constant nebulæ may be thus accounted for, and their irregularities of shape may have arisen from different accidents of the concussion; but changes of magnitude have been observed even in these bodies. The origin of new stars that remain may be explained by supposing that the concussion was less violent—strong enough to produce a great brightness, but not strong enough to cause immense expansion. Professor Ritter claims that spectroscopical observations of the "newer stars" are in harmony with his theory.

A newly discovered Jewish Tribe.—Mr. Henry Samuel Morais has published a short account of the Daggatouns, a tribe of Jewish origin in the Desert of Sahara, recently brought into notice in the narrative of the Rabbi Mordecai Aby Serour, of Akka, Morocco. The rabbi's account is incomplete, but we may learn from it that the people mentioned, who are scattered among the orthodox Tuaricks in the desert, "have skins perfectly white, are very handsome, much handsomer than the finest-looking Jews of Africa," and that not one of them is black. They are distinguished by the Tuaricks as Jews that have changed their belief, and seem to occupy a low social position among the tribes. The change in belief seems rather to have been a loss of belief, for it is remarked respecting the exercise of their religion that they never utter a prayer, and have no regular form of public worship, but simply invoke the name of Mohammed. To questions on the subject they emphatically answered that they did not know the Koran, and that, having descended from the Jews, and not resembling in any manner the other tribes, they could not have exactly the same religion. "Notwithstanding this," they continued, "even if we accepted their practices, they would not cease calling us converted."

The Eucalyptus in California.—Mr. Robert E. C. Stearns, Ph. D., communicated to the American Forestry Association, at its recent meeting, a number of facts respecting the cultivation of the eucalyptus in California, and the probable value of the tree. About six million eucalyptus-trees have been planted in the State during the last ten years, and several million trees of other kinds. A large proportion of the number have been planted in the streets and yards of cities, and for ornament in country estates, till, in the absence of deciduous trees, "the vistas afforded by the streets are somber and monotonous through general sameness of form and tone of color." The eucalyptus is a greedy monopolist, and, when planted in a small yard, takes all there is of it, killing out the shrubs. These objectionable facts, however, are not faults of the tree *per se*, but are only effects of injudicious planting, remediable by remanding the eucalyptus to its proper place, and by interspersing it with native and deciduous trees, for the sake of variety in the appearance. The *globulus* species of eucalyptus is the one most planted, but it is probably of less value for most purposes, aside from the fact of its rapid growth, than its harder-wooded congeners. This species, also, "which seems generally to thrive within the influence of the coast climate, where the saline quality of the coast atmosphere neutralizes the occasionally too low temperature of the winter months, often fails in the interior. 28° Fahr. is about the temperature limit as to cold." Touching the value of the eucalyptus for lumber, based upon the product of California-grown trees, "but little can be said. The time has not arrived to determine that question. The

lumber sawed in Australian mills is not made from trees of only ten to fifteen years of age, and it is probable that very few of the eucalypts planted in California are as old as fifteen years from the seed. Our native trees of so recent growth are not used for or made into lumber, and nothing but soft and sappy wood can be expected from trees so young." Facts bearing upon the profit of eucalyptus-growing for fuel purposes are furnished by the yield of twenty acres of a plantation belonging to General Stratton, of which, after charging every item of cost, and a yearly rental of five dollars per acre, the net profits were $3,866.04 in eleven years. Notwithstanding that too much may have been claimed by enthusiastic friends in relation to the sanitary and medical value of certain species of the eucalyptus, "there is enough, minus exaggeration, to justify their being regarded as of unquestionable merit."

How Flies climb.—Herr H. Dewitz has communicated to the Berlin Society of Natural History some facts that bear very strongly against the generally received theory that flies adhere to perpendicular walls and ceilings by virtue of some sucking power in their feet. He asserts that the feet of flies can not possess the sucking property ascribed to them, for they are hard and destitute of muscles. The theory has long been contradicted by the experiments of Blackwall, who found that flies could climb the sides of a jar under the receiver of an air-pump, where there was no atmospheric pressure; and who asserted that the power of adherence was due to a sticky matter secreted from the foot-hairs of flies. This assertion was generally regarded as not proved, and the case has rested there. Dewitz reports that his investigations have shown that Blackwall was right. He has watched the exudation of the sticky matter from the feet of the flies by fastening one of the insects to the under side of a plate of glass and viewing it under the microscope. A perfectly clear liquid was seen to flow from the ends of the foot-hairs and attach the foot to the glass. When the foot was lifted up, to be put down in another place, the drops of the sticky matter were perceived to be left on the glass, in the exact places where the foot-hairs had rested. The adhesive fluid appears to pass down through the hollow of the hair, and to be derived from glands which Leydig discovered in the folds of the foot in 1859. A similar adhesive matter appears to be possessed by bugs, by many larvæ, and probably by all insects that climb the stems and the under sides of the leaves of plants.

Flesh-eating no Sin.—Mr. W. Mattieu Williams gives a pointed answer, in the "Journal of Science," to the protests of a vegetarian writer against eating animal food, on the ground that it involves cruelty to living beings. No animals, he says, enjoy a more comfortable life, or are better cared for, than those we keep for food. If we did not eat them, they would be exterminated, for they would not be able to take care of themselves. Yet, in the very sight of the wonderful animal happiness that they enjoy, "the sentimental vegetarians advocate the extinction of all the pastoral bliss that has been a leading theme to poets of all ages." The final killing of them is in accordance with the order of nature, and, if we are to be denounced for it, the Creator must also be denounced for giving life, and at the same time making death one of its necessary conditions. Then, if the killing is wrong, the vegetarian kills on a far more extensive scale, "for the boiling of a cabbage involves the immolation of innocent slugs and caterpillars, and tens of hundreds of thousands of aphides are sacrificed in topping a row of broad beans, to say nothing of the millions of Colorado beetles that have been mercilessly murdered in order that ruthless, selfish man may satisfy his greed for potatoes."

Sun-Worship and the Cross in Ancient America.—Mr. F. L. Hilder, of the Missouri Historical Society, has made a study of a pottery-vessel taken from one of the mounds in the State, and finds that the ornaments upon it represent the sun, figured under four distinct designs. He draws the conclusion, from his examinations, that "the symbolic character of all these devices is so evident that it is impossible to mistake their meaning. They are all well-known emblems of that solar worship which was

so prominent in all the primitive religions of the world that it has completed the circuit of the habitable globe. As such they form an important item in the evidence to establish the fact that the symbolism employed by the ancient inhabitants of this region was far too refined and abstract to have been the outgrowth of the religious ideas of savage hunters and warriors; and that it bore a close analogy to, if not absolutely identical with, that in use among the nations of the central part of the continent when invaded by the Spaniards." In one of the forms of the figure, the sun is marked with a cross, thus giving new evidence of the universality of that symbol among mankind.

The Bacilli of Tubercle.—The "Medical Press" gives one of the clearest accounts of the experiments by which Dr. Koch has established the bacterial origin of tubercle. In pursuing his investigations, Dr. Koch used material derived both from human and animal sources. Examination of the tuberculous material deposited in various organs led to the discovery of minute organisms possessing all the bacterial characteristics of bacilli, whence the conclusion was formed that those forms of life are invariably present in such deposits. In a multitude of cases of miliary tuberculosis, bacilli in incalculable numbers were encountered in every affected situation, and the conclusion was warranted that they inevitably accompany the development at least of the disease. To demonstrate, however, that they are the cause of the affections, required the accumulation of sufficient actual proof, and Koch's claim to the gratitude of the world rests on the fact that he appears to have made this. Numbers of Guinea-pigs, rabbits, and cats were operated upon, with the result, in every case, of verifying the conclusions which the experimenter had reached. By directly transferring the tuberculous matter from diseased animals to healthy ones, through inoculation, Dr. Koch succeeded in all cases in reproducing the disease. As, however, it was still possible that the contamination might be due to a virus contained in the transferred material, rather than to the presence of microscopic organisms in it, "cultivation" experiments were introduced and conducted on a very exhaustive scale. A pabulum was found in which the bacilli grew and reproduced freely. By repeated sowings in new quantities of the nutritive matter, extending in some cases to six months, a generation of "purified" bacilli was obtained which could not by any possibility be accused of communicating virus. When these organisms were introduced into healthy animals, they never failed to reproduce themselves in incalculable numbers, and to set up all the symptoms of tuberculous infection. Thus, four Guinea-pigs were inoculated with bacilli of the fifth generation produced in fifty-four days from tuberculous matter originally derived from a human being. In each case the infected animal sickened and lost flesh, and was found when killed to have strongly pronounced tuberculosis. This took place whatever was the point in the body chosen for the injection of the infective material. When some animals were injected with healthy blood-serum at the same time that others were inoculated with bacilli, the latter sickened and became tuberculous, while the former were not affected. In another series of experiments the sputum of phthisical patients, even after having been thoroughly dried, was found to produce similar effects with the bacilli. Certain conditions seem essential to the development of the bacilli under the ordinary circumstances of communication, and further experiments will bear reference to ascertaining precisely what they are.

Neglect of the Study of Insanity.—In a paper read before the National Association for the Protection of the Insane and the Prevention of Insanity, Dr. Nathan Allen, of Lowell, Massachusetts, calls attention to the neglect in which the study of insanity is left by the medical profession generally. Acknowledging that the study of the functions and disorders of the brain presents more difficulties than any other branch of medical science, but seemingly considering this as only a stronger reason why more attention should be given to it, he finds that in very few instances is insanity mentioned as one of the subjects in the annual circulars of medical schools advertising their lectures. In only three or four schools is there a professorship or course of lectures de-

voted exclusively to mental disorders. The subject is sometimes introduced under the head of theory and practice of medicine, but is more often remanded to the lectures on medical jurisprudence; and hardly ever is a book on this subject included among the standard works of study and reference proposed for students.

The Albert Medal.—The Albert Medal of the British Society of Arts has been awarded, beginning in 1864, to Sir Rowland Hill, for postal reforms; to Napoleon III, for his promotion of art; to Professor Faraday, for discoveries in electricity, magnetism, and chemistry; to Mr. W. Fothergill Cook and Professor Wheatstone, for establishing the first electric telegraph; to Mr. Joseph Whitworth, for his instruments of measurement and uniform standards; to Baron von Liebig, for chemical and other researches; to Ferdinand de Lesseps, on account of the Suez Canal; to Mr. Henry Cole, C. B., for activity in international exhibitions and the South Kensington Museum; to Mr. Bessemer, for developing the manufacture of steel; to M. Chevreul, for chemical researches; to C. W. Siemens, for a variety of researches; to Michael Chevalier, for general economical activity; to Sir George B. Airy, for researches in nautical astronomy and magnetism, etc.; to M. Dumas, for chemical researches; to Sir William Armstrong, for distinguished engineering work and development of mechanical power; to Sir William Thomson, for electrical researches and the development of ocean-cables; to J. P. Joule, for establishing the relations between heat, light, and electricity; and to A. W. Hoffmann, of Berlin, for investigations in organic chemistry and his promotion of chemical education and research in England. The award of the medal for 1881 was to be made in May.

Tree Meteorology. — Mr. Robert E. C. Stearns, Ph. D., at the close of a paper on the estimation of the annual growths of certain trees in California, suggests the possibility of making valuable investigations into the periodicity of climates and the direction and effects of prevailing winds by the systematic study of the year-rings of trees. "We might," he says, "find so close a parallelism between rings of maximum thickness and seasons of maximum rain-fall, that we should be justified in regarding this parallelism as something more than a series of coincidences merely, by finding these coincidences so persistent as to prove a correlation; and we could, perhaps, base our weather prognostications on something more than a guess, and learn whether or not there is a periodicity or cyclical term of wet and dry years, having the data before us according to the trees selected and examined—reaching back with the pines from seventy-five to one hundred and fifty years, with the redwoods from five hundred to seven hundred years, and with the sequoias of the Sierra from twelve to fourteen centuries, to say nothing of the testimony of other trees, the madronas and oaks especially. Differences in the diameters of trees," Dr. Stearns adds, "may be traced, perhaps, to a difference in the amount of heat and light which one side of a tree receives as compared with the other; to the influence of prevailing winds according to the station, position, or exposure, or to local or general magnetic influences—local as peculiar to small areas, or general as pertaining to larger or extensive regions. An accumulation of data might show a marked and constant character in the relation of diameters to such factors of the environment; and also a marked character in the diameters of one region, as a whole, when compared with another region, where modified or different climatic conditions exist."

Habits of Wood-Ducks.—The experiments of Mr. George Irvin, of Mayville, New York, upon the capacity for domestication of different species of wild ducks, gave him the means of gaining much knowledge of the habits of the wood-ducks, which, although they would not be domesticated, bred freely within the inclosure in which he confined them. They generally begin to nest about the middle of April, and always choose trees with suitable holes and hollows in which to build, preferring for this purpose rather high elevations, and lay from nine to fourteen eggs, of a yellowish-white color, the period of incubation of which is four weeks. When the young

birds, twenty-four hours after being hatched, are ready to descend from their nests, whether low or high, the old bird comes to the mouth of the hole and takes for about a half-hour a careful survey of the surroundings, to ascertain, as it were, that no intruder is near, and then utters a low call. The ducklings seem to understand the significance of the call and quickly make their appearance in front of the hole, which often extends to a depth of from six to ten feet. By means of their toe-nails, which are hooked nearly as much as those of birds of prey, and sharp as the point of a needle, they easily manage to climb up on the inside of the deep holes, at the entrance of which they remain a few minutes huddled together about the old bird. After this, the mother again descends to the ground near the tree, and calls upon her young brood, which now drop, one by one, from their airy perch, without any apparent hesitation; for their bodies are already so thickly covered with down that they seem to fall like leaves to the ground. When the last duckling has accomplished its fall, the brood gather again about the old bird and are led by her to the nearest water, which is seldom far away, and is generally convenient to shelters and hiding-places.

The Foot, and how it should be treated.—The human foot is an instrument admirably adapted to all the various uses it has to serve, which fashion has done its best to spoil by improper treatment. The bones of the instep are so adjusted as to form an arrangement which combines in exquisite perfection the resistance of the arch with as much elasticity as enables it to bear safely the prodigious strain to which it is subjected. The whole frame of the foot is kept in position and made capable of its proper range of movement by means of muscles and tendons, constituting a living and sensitive bandage, increasing or relaxing its pull or pressure in the most exact obedience to our will. In a sound, free foot, each part of the machinery is in constant readiness to bring it into the required position, whether to lift the body, to bound, or to sustain the shock of the whole weight in coming down again, or to perform any other of a number of complications of movement. How perfectly the foot is adapted for these purposes, and is protected against too great pressure and sudden shock, is shown by the fact that such violent actions as leaping, or the being burdened with a weight twice or thrice that of the whole body, cause no uneasiness to a sound foot; the injury, if any, resulting from such exertions being usually felt elsewhere. The skin, very thin and delicate on the upper part of the foot, is thick and tough, though soft and pliable, on the sole. Beneath it is a layer of fat, strengthened by strong fibers crossing it and binding it to the muscles and ligaments. The sole can endure great pressure and even violent shocks, but is at the same time curiously sensitive, especially to the touch. It is very easily tickled. This property serves a very important purpose in walking, for the pressure upon the ground stimulates the muscles of the foot to their required activity, without any effort of the will, and indeed without our being conscious of the operation. This spontaneous alertness of the muscles, on which the energy and grace of movement depend, can be secured only by their being kept uncramped, free, and well exercised. How much the shoemaker's shoes, cramping the foot, jamming the toes upon each other, distorting the shape of the organ, and lifting the heel up so that the weight of the body is thrown upon the toes, prevent this, needs no elaboration. The lesson of these observations is that the shoe should give plenty of room all around to the foot, that the sole should be thinnest and narrowest at the "waist," where elasticity is wanted, broad and thick at the tread, where protection is most required, and that no one should be ashamed of the size of his foot. "A well-formed large one is a far pleasanter sight than the smallest one distorted."

A Lion-Tamer's Method.—A curious history, and one that sheds many gleams of light upon the character of beasts in the menagerie, is that of Henri Martin, the lion-tamer, who died, ninety years old, quietly at his home, "among his collections of butterflies and his books of botany." Martin, according to his own letters, began to cultivate his gift of control over animals in the days

when he was connected with a circus, by acquiring an extraordinary power over horses, which he taught every trick known to the profession, and some which have hardly been exactly paralleled. From this he went on to taming wild beasts; and, soon after he had started business as part proprietor of a menagerie, he had labored eight months in training a royal tiger, and had taught a spotted hyena to pick up his gloves. He was never seen with a whip in his hand; but he crossed his arms, and gave his animals the word of command to leap on and off his shoulders; and he considered his method infinitely superior to that of the tamers who go through their business chiefly by the terrorism of a heavy whip and a revolver. Their beasts obey them, but, he said, "they are not tamed as mine were, and, when one of them rebels, you can judge the tragic result from the tragical end of Lucas." One day, Martin told his wife that he anticipated trouble with his lion Cobourg, who was then in a dangerous state of excitement. She begged him to put off the performance, but he said: "No; for, if I should do it once, I should have to do it every time the animals have caprices." The next night his forebodings were fulfilled. Instead of performing his part properly, Cobourg crouched low and dug his talons into the stage, and his eyes flared. Martin had no weapon at command except a dagger in his belt—"I have said, never a whip." Instead of obeying orders, the lion leaped at Martin, and a combat occurred, in the course of which the lion took Martin up in his mouth and shook him in the air. Martin struck the animal over the nose for a second time, and then, feeling his strength exhausted, gave himself up for lost, and turned his back to the beast, so that at the next spring it might attack the back of his neck, and so "make an end of the business. . . . But two seconds passed, two seconds that seemed to me an eternity. I turned around; the lion's mood had changed. He looked at the audience, he looked at me. I gave him the sign to go. He went away as if nothing had happened." It was fourteen weeks before Martin could perform again, but then the lion worked well as usual, and continued to do so for four years without any more caprices. In taming one of his tigers, Martin began by taking the brute's attention off the door of the cage, and then, armed with a dagger, went rapidly into the cage and stood looking at the tiger, which for some minutes lay motionless, staring at him. Then, feeling a shiver, and knowing that if the tiger saw it all would be over with him, he went swiftly out. At the end of a fortnight he went again into the cage, and this time staid there half an hour. A third time he paid the tiger a visit of three quarters of an hour. "The fourth time the tiger, trembling at first, lay down before the pygmy who braved it." To tame a hyena, Martin wrapped his legs and arms with cords, and protected his head with handkerchiefs, and then, walking into the cage, went straight to the animal and offered it his fore-arm. The hyena bit it, and the tamer, looking steadily in its eyes, stood motionless. The next day he repeated the experiment, substituting a leg for an arm; "and all the time Martin's black pupils were flashing into the gray eye of the hyena. The beast gave up, cringed, and smelled the feet of the master." Martin tamed his subjects by his personal influence alone; and Charles Nodier once said of him: "At the head of an army Martin might have been a Bonaparte. Chance has made a man of genius a director of a menagerie."

A Merovingian (Frank) Grave-Yard.—M. Georges Lecocq has described some articles which he has recovered from a cemetery of the Merovingian period at Caulaincourt, France. He opened 186 graves, and found in them 156 coffins of wood, 30 of stone, and 464 articles of glass, iron, bronze, ivory, coins, beads, flints, etc. The graves were generally well aligned and directed from east to west. The stone coffins were made, some from a single block, more from two or three blocks, and were wider at the head than at the foot. The covers were flat or tectiform, and always composed of two or three slabs. These sarcophagi all contained wooden coffins. In most of the burials a stone was placed over the breast. The race of men whose burial-place this was, do not appear to have been essentially different from the present race. One skull, which particularly attracted attention, had a hole in it exactly like what

a gunshot would produce. The numerous articles of earthenware presented a great variety of forms, and were both plain and decorated. The iron articles were all very much oxidized, so that traces could hardly be detected of the silver with which some of them had been damascened. Lances were put at the head of the dead and arrows and battle-axes along by the legs. The bronzes were made of different alloys of copper and tin and other metals, and included fibules in the shape of a bird (single- and double-headed paroquet), round belt-plates, and handsome little shoe-ornaments.

Egyptological Discovery.—Great progress has been made within twelve months in Egyptological discovery. M. Marriette, the official curator of the antiquities of the country, who died in January, 1881, had, just before his death, opened three pyramids, two of them those of monarchs of the sixth dynasty who were among the most distinguished kings of the old empire—Pepi Rameri, who, according to Manetho, reigned a hundred years, and his son and successor Rameri. The pyramids were richly adorned with inscriptions, and the discovery pleasantly supplements the valuable biography we already had of a chief officer of that period, relating the wars with the negroes and other events, which form one of the most satisfactory historical documents which the ancient empire has yet furnished us. Professor Maspero, who was appointed to succeed M. Marriette, shortly after he took his office explored the pyramids of a still earlier monarch, Unas, the last king of the fifth dynasty, which was also richly decorated and contained inscriptions, mostly parts of the ritual, a sarcophagus of black basalt, and remains of the mummy, bearing marks of the work of the ancient tomb-breakers. The excavations of the pyramids are to be continued in the expectation of finding them to confirm M. Maspero's theory that the pyramids from Gizeh to the Fayoom are a series containing in succession the bodies of the kings from the fourth to the thirteenth dynasty. A second great discovery of no less importance was made in July at the caverns behind the Deir-el-Bahari, or temple of Hatasu, near Thebes. Attention had long been drawn to the antiquities which had been offered to travelers for many years past, and which it was believed must come from some hiding-place known only to the Arabs. M. Emil Burgsch secured the arrest of the Arab who seemed most concerned in these dealings, and succeeded in tracing the articles to their source, the cave among the hills where the royal mummies had been carried and deposited for security against invasion during the twenty-first dynasty. The mummies are twenty-seven in number, several of them being of kings, queens, and princesses, and persons of distinction of the eighteenth and intervening dynasties to the twenty-first, and with them were thousands of objects—amulets, statuettes, papyruses which are expected when read to prove of great value, and a leather tent of a king of the twenty-first dynasty. Among the mummies are those of Raskenen, a king preceding the eighteenth dynasty; of Queen Ansera, Amenophis I, and his wife Ahmes Nofertari, Thothmes II, and Thothmes III, of the eighteenth dynasty; Rameses II, the supposed Pharaoh of Moses, of the twentieth dynasty; Queen Notemit (to whom the "Prince of Wales's papyrus" in the British Museum was originally attached); and King Pinotem II, of the twenty-first dynasty. Cases and other articles were also found belonging to other distinguished monarchs of the eighteenth and nineteenth dynasties, The cave in which the remains were found is supposed to have been originally the tomb of Queen Ansera.

The Manageable Zone of Anæsthetics.—M. Paul Bert has announced some discoveries of great value respecting the mode of action of mixtures of anæsthetic vapors and atmospheric air upon the animal organism. He applies the term *manageable zone* to the different degrees of admixture, rising from the proportion of anæsthetic which is insufficient to put to sleep, to the proportion which will cause immediate death. In the case of chloroform and ether the mortal dose appears to be exactly double the minimum anæsthetic dose. Anæsthesia takes place in the middle of the manageable zone very rapidly and without danger, so that the animal may be left for two hours in the anæsthetic atmosphere without any one being concerned about him.

It is not necessary to insist upon the contrast thus afforded between this method of administration and the one that has hitherto been used, in which the operator, making his patient breathe dense chloroform directly into his nostrils, has to exercise the greatest caution lest he kill him. The manageable zone of ether is a little more than three times as wide as that of chloroform, while that of the protoxide of nitrogen is considerably wider than that of ether. Here we see why ether is less, and the protoxide of nitrogen still less, dangerous than chloroform. M. Bert's researches further show that it is not so much the absolute quantity of the anæsthetic that should be regarded as the proportion in which it is mixed with air. A dog can safely be made to absorb many times as much chloroform as would kill him, if it were pure, provided it is so diluted as to bring its strength within the manageable zone.

Poisonous Food-Colors.—The prefect of police of Paris has expressly forbidden the use of any of the following substances in coloring sweetmeats, liquors, and foods: *Mineral Colors.*—The compounds of copper—blue verdigris, mountain blue. Compounds of lead—oxides of lead—massicot and minium. Oxychloride of lead—Cassel yellow, Turkey yellow, Paris yellow. Carbonate of lead—white-lead, flake-white. Antimoniate of lead—Naples yellow. Sulphate of lead. Chromates of lead—chrome yellow, Cologne yellow. Chromate of baryta—yellow ultramarine. Compounds of arsenic—arsenite of copper, Scheele's green, Schweinfurth green. Sulphide of mercury—vermilion. *Organic Colors.*—Gamboge and Naples aconite. Fuchsine and its sub-products, such as Lyons blue. Eosine. Nitro-derivatives, such as naphtol yellow and Victoria yellow. The use of these substances in coloring wrapping-papers for any kind of food is prohibited, and manufacturers and dealers will be held responsible for any accidents that may occur through disobedience of the prefect's order.

The Meteorograph.—Messrs. Van Rysselberghe and Schubert exhibited at the Paris Exposition of Electricity an instrument they called a meteorograph, for representing by means of continuous curves drawn automatically upon a sheet of zinc all the principal atmospheric variations, the knowledge of which is indispensable in meteorological investigations and in making forecasts of the weather. M. Theorell, of Stockholm, exhibited another machine, of a more complicated character, which indicates, by printed figures in six columns on an endless roll of paper, the hour when the observation is taken, the velocity of the wind, its direction, the indications of the wet and of the dry thermometer, and the indications of the barometer. Notwithstanding the complicated character of the machinery that must do so much, the instrument has borne admirably the test of use at the University of Upsala, where it has been employed for two years in registering the condition of the atmosphere every quarter of an hour. For immediate use in the observatory it is not as convenient as the Rysselberghe instrument, the graphic curves of which can be read off and appreciated at sight; but it is much its superior for use in cases where the facts have to be transmitted by telegraph.

Sea Telegraphy for Ships.—M. Menusier has proposed a plan of telegraphy for the use of ships at sea. Upon his cable, which he would lay from the French coast to New York, with a branch to Panama, he proposes to ingraft at distances of about one hundred and eighty miles, representing a ship's daily sailing distance, vertical cables rising to the surface where the ends may be held up by buoys. To the main cable he would also add secondary cables thirty or sixty miles long, forming cross-cables, like great arms stretching out on either side, to which other vertical cables would be attached, each to be held in place by its surface buoy. Thus it could rarely happen that a ship keeping on the regular course would not be able to meet one of the buoys every day. Each buoy should have its number and its place marked on a special chart. If a ship wishes to send a dispatch, it attaches the wires of its own telegraphic apparatus, one to the cable that is held up by the buoy, the other to the buoy itself, which is of course in communication with the earth-currents. M. Menusier professes to solve the principal difficulty in the way of the successful oper-

ation of his invention, which is that of fixing the buoys so that they shall not be removed by storms, but declines to make his plans public on account of the defective condition of the patent laws. He has, however, explained it to competent navigators, and they are said to regard it as practicable.

American and European Palæolithic Implements.—Mr. Henry W. Haynes has compared the argillite implements found in the gravels of the Delaware River at Trenton, New Jersey, with the palæolithic implements of Europe, by a personal inspection of both, to ascertain to what extent they correspond in character as objects of human workmanship. He traces many striking resemblances between the two groups. The argillite implements are, indeed, of ruder workmanship than the European flints, but that is because the material from which they are made is less susceptible of being finely worked. The types of the two classes of implements are, however, remarkably similar, and the Delaware objects are equally well adapted to any purposes to which the European implements are capable of being applied. Regarding the character of the formations in which the implements are found, the general appearance of the country and the gravels present a striking resemblance to what he has seen in the places where the palæolithic implements in Europe were found. He, therefore, considers the argillite objects of the Trenton gravels to be true palæolithic implements.

Disease from Coal-Dust.—M. Paul Fabre has published some observations on the part which coal-dust plays in the pathology of coal-miners. The effects which result from the accumulation of dust in the respiratory passages are obvious and need no particular description. Coal-dust does not exert any special action on the skin. The parasitical pests, the origin of which some authors have attributed to coal-dust, never appear except when the chambers of the mines contain water holding some irritant in solution or suspension. Coal-sorters, who work on the surface, live in an atmosphere containing coal, and handle as much coal as the workmen in the mines, but do not suffer from eruptions. Nearly all miners are marked with characteristic scars of a clear blue color, which, indelible as real tattooing, follow every wound produced by splinters of coal. Coal-dust in the air in a state of suspension may produce a slight degree of simple conjunctivitis; affections of the cornea and iris are also sometimes observed, resulting from blows inflicted by fine fragments of coal. They are generally cured after the irritating splinter has been removed. Miners are frequently affected with defective hearing and other troubles of the ears, which most frequently arise from a stoppage of the extreme auditory conduit with masses of dust that have been cemented into a wad by the ear-wax. This may be easily removed, and the irritation of the ear-passages may be cured afterward by washing.

What Perils might come out of a Tunnel.—The scheme to tunnel the Channel has excited great alarm, and called out formidable remonstrances in England. The objection most prominently urged against the proposed work is that it would expose the country to a constant menace of invasion or treachery. The French might fill the tunnel at any time with soldiers in the guise of innocent passengers, and seize the English approaches so firmly that it would be impossible to shake them off, before the people had begun to imagine that danger was near; and the Irish republicans might form a league with the French, and, seeing that the telegraph wires were cut, destroy communication within the kingdom, thus increasing the danger, which, as it was previously presented, seemed as great as it possibly could be. The single defense of the English would be the power of blowing up the tunnel suddenly and unexpectedly, "and what would that power be worth? The premier might think himself justified in destroying twenty millions of property and impairing twenty-two millions more; . . . but also he might not. He might be an undecided man, or a man expecting defeat by the opposition, or a man paralyzed by the knowledge that the tunnel was full of innocent people whom his order would condemn to instant death in a form which is at once most painful and most appalling to the imagination. . . . The

responsibility would be overwhelming for an individual, and a cabinet, if dispersed, takes hours to bring together." The danger of panic, to which the people and the markets would be constantly exposed, in the view of such apprehensions as these, is one the effects of which would be real. Such objections to the tunnel have found formal expression in a remonstrance which has been signed by men whose names carry weight everywhere, and have at last brought about a suspension of the project. A very curious objection, which Americans can hardly appreciate, is suggested in "The Spectator." It is that the tunnel would turn England into an outlying peninsula of the European Continent, and "would be almost purely mischievous, as slowly destroying the insularity and separateness of the national character."

Color-Names and Color-Sense.—Dr. B. Joy Jeffries, in an article in "Education," calls attention to the fact that the power to give right color-names does not indicate the possession of a right perception of colors. "A blind child will give the name of the color of grass, trees, apples, bananas, bricks, its companion's clothes, and perhaps even of hundreds of objects, the color-name of which it has learned. So, also, the color-blind boy will do the same. It is one thing to learn the color-name connected with a remembered object, and a very different thing to connect the right name with the sensation a green color arouses. Here has been the mistake which object-teaching has rather fostered than corrected." It is evident, he adds, that teaching color in the schools must embrace the detection of color-blindness in the boys, the learning the names of the commonest colors at least, the sharpening of the appreciation and discrimination of colors, and thus the gradual education of the color-sense. Instruction should begin in primary or Kindergarten work, and be steadily pursued through school-life. Congenital color-blindness is incurable, but it may be somewhat palliated. It is not exhibited as strongly in artificial as in natural light. Looking through a piece of lemon-colored glass will help the color-blind in daylight or electric light; and the same is true of looking through a solution of gelatine stained with fuchsine. No temporary or permanent change takes place in the color-sense under these circumstances, but alterations of light and shade are made which the color-blind have learned, unconsciously, to avail themselves of.

NOTES.

In our notice, in the July number, of the death of Professor W. B. Rogers, we ascribed it, following the newspaper reports, to apoplexy. We now learn from his brother, Professor R. E. Rogers, that the deceased died from heart-disease. Professor Rogers's physicians pronounced the cause of his death to be "an attack of the heart, in which life was extinct before his body reached the floor."

Antoine Breguet, co-editor with Dr. Charles Richet of the "Revue Scientifique," in Paris, died of a disease of the heart on the 8th of July, in the thirty-second year of his age. He was distinguished in science chiefly as an electrician, and took a conspicuous part in the management of the International Exposition of Electricity of last year. Among his earlier writings was a paper on the theory of the Gramme machine, which was published in the "Annales de Chimie et de Physique." He contributed many articles to "La Nature" between 1875 and 1878; and became co-editor of the "Revue Scientifique" on the retirement of M. Alglave from that journal in 1880.

Mr. Albert S. Gatschett, in a study of the Indian languages of the Pacific States and Territories, and of the Pueblos of New Mexico, disputes the affinities which are supposed by many to exist between the Aztecs and the Pueblos. The oldest and most important characteristics of race and language, he alleges, are far from being common to both races, and even secondary and more recent characteristics, as implements, manners, customs, laws, government, religions, beliefs, worship, and traditions, have not been shown to be identical in them. A comparison of all of the four languages of the Pueblos of New Mexico and Arizona results in showing that none of them have sufficient affinity with Aztec to justify a classification with it.

The French Department of Public Works reports that of the 39,938,126 metres representing the total length of the national highways of the country, 23,731,928 metres may be bordered with trees. Of this distance, 14,335,311 metres have already been planted with 2,691,698 trees, leaving 9,396,617 metres yet to be planted.

The editor of the "Medical Press" has visited a canary-bird, in the possession of Dr. J. MacGrigor Croft, that can talk. He says he found that the bird could pronounce a good number of sentences, "clearly imitative of the voice of the lady who had care of it since its early youth," and that "the effect produced by the clear, sweetly uttered sentences pronounced by the bird is almost weird at first; but the feeling of wonder thus created quickly gives rise to a sensation of exquisite pleasure, which is deepened as the little creature suddenly, at the end of a sentence, rushes off into an ecstasy of song."

Mr. Craig, of Montreal, has produced a novel effect in the electric light by the device of placing his reflectors under the light and throwing the rays upward to the ceiling. It is found that by using this method the light, as reflected back from the ceiling, falls upon the persons below much softened, and far more agreeable in tone than when reflected directly downward in the usual way. The glaring center of light is hidden by the reflector below it, and no longer offends the eyes. Objects not exposed to direct light are not in shadow, as in cases of ordinary reflection, but the whole effect is described as like that of the sun in the zenith.

Mount Etna has been in a half-active condition ever since the great eruption of 1879. Hardly a month has passed in which it has not ejected smoke and sand with greater or less violence and persistency. The outbursts have been accompanied by the strong tremblings of the ground, and the intense subterranean noises which commonly precede the great eruptions, but there has been no emission of lava. Such frequency of eruptive paroxysms, ending in simple jets of dust, is unprecedented in the long history of Etna.

The "Echo of Japan" says that a cave near Beppo-Moura, Japan, had not been entered by any one for several generations. According to popular belief, a god made his abode there, and was ready to punish with death any one who violated his privacy. One of the tribe of doubters recently ventured in, and found there the veritable god whom the mass of mankind worship. The ground was strewed with nuggets of gold. A preliminary examination of the spot has been made, and shows that it is extraordinarily rich in the precious metal.

It is estimated that twenty-nine per cent of the acreage of Europe is still in timber. Forty per cent of the enormous territory of Russia is in forests, and of this two hundred million acres are in pine-woods. Thirty-four per cent of the territory of Sweden and Norway is occupied with woods of useful timbers, twenty-six per cent of Austria, twenty-seven per cent of Germany, seventeen per cent of France, seven per cent of Spain, the timber being cork, oak, and chestnut, five per cent of Portugal, and four per cent of Great Britain. Scotland is the only part of the British Empire (including the colonies) in which the planting of timber is going on to any considerable extent. Sweden is now the country from which the world's supply of fir timber and deals chiefly comes.

Dr. J. R. Black of Newark, Ohio, in a lecture delivered at Columbus, makes a well-conceived plea for giving more attention to physical education, saying: "To impart a knowledge of the three R's is well, but is it not as well to impart a knowledge of how to live healthy lives? Is not a strong, healthy, self-made man better than a highly cultured weakling? Let the State, as educator, attend to this point, earnestly and thoroughly, and the results would be that, besides gaining for itself a better soldiery in times of peril, there would also be an increased immunity from crimes against the State, a diminution of the conditions which produce disease and pauperism, and the rendering of the life of each more joyful and serene."

In a paper on the aurora of April 16 and 17, 1882, which was read before the American Philosophical Society, Mr. H. Carvill Lewis points to the occurrence of remarkable auroral displays at this time, as affording a striking confirmation of the periodicity of these phenomena. "It is just ten years," he says, "since the last auroras of importance occurred, and the period of ten to twelve years between maximum auroral displays may be regarded as firmly established. The coincidence of this period with that of most numerous sun-spots shows a direct connection between the electrical condition of the earth and sun. At the present time the sun is exhibiting remarkable disturbances."

News has been received in Paris of the death of Dr. Crevaux, who had started from Buenos Ayres on a second exploring expedition in South America, designing this time to ascend the Paraguay River and its tributaries and thence pass to the valley of the Amazon, whence he would descend the Tapayos. His company appears to have been murdered by a horde of cannibals. On his previous expedition, in 1879, he determined with the compass the course of six rivers, two of which belong to Guiana, and four are tributaries of the Amazon. While a little was known of three of these rivers, the Maroni, Oyapok, and Issa, two of them, the Parou and the Yari were virgin to all exploration, and of the Japura, which is fifteen hundred miles long, four fifths of its course were unknown.

RUDOLF VIRCHOW.

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MASSAGE: ITS MODE OF APPLICATION AND EFFECTS.

BY DOUGLAS GRAHAM, M.D.

"MASSAGE," from the Greek *masso* (I knead or handle), is a term now generally accepted to signify a group of procedures which are usually done with the hands, such as friction, kneading, manipulating, rolling, and percussing of the external tissues of the body, either with some curative, palliative, or hygienic object in view. Its application should in many instances be combined with passive, resistive, or assistive movements, and these are often spoken of as the so-called Swedish movement-cure. There is, however, an increasing tendency on the part of scientific men to have the word "massage" embrace all these varied forms of manual therapeutics, for the reason that the word "cure," attached to any form of treatment whatsoever, can not always be applicable, inasmuch as there are many maladies that preclude the possibility of recovery and yet admit of amelioration. Hence the word "cure" may lead people to expect too much; and, on the other hand, the use of the word "rubbing" in place of "massage" tends to undervalue the application and benefit of the latter, for it is but natural to suppose that all kinds of rubbing are alike, differing only in the amount of force used.

According to the requirements of individual cases, massage may be of primary importance or of secondary importance, of no use at all, or even injurious. Concerning the extent of its usefulness, it may with safety be said that, at tolerably definite stages in one or more classes of affections in every special and general department of medicine, evidence can be found that it has proved either directly or indirectly beneficial, or led to recovery, sometimes when other means had been but slowly operative, or apparently had failed altogether.

In view of these facts, it need hardly be said that those who would properly understand and apply massage should be familiar with its past and present literature; they should also be familiar not only with the natural history of the maladies in which massage may be applied when left to themselves, but also with the course of these affections when treated in the usual approved methods, so that improvements or relapses may be referred to their proper causes. Moreover, they should know something about the methods of others who have any claim to respectability in their manner of applying massage, so as to compare them with their own. And yet all these qualifications may fail if the operator has not in addition abundance of time, patience, strength, and skill, acquired by long and intelligent experience. Measured by these requirements, I fear that good *masseurs* (manipulators) are scarce. Dr. E. C. Seguin, in the "Archives of Medicine" for April, 1881, says, that even in New York there are few manipulators who can be trusted to do massage well. Massage may be studied as a science, but it has, like everything else in medicine and surgery, to be practiced as an art. Those who have a natural tact, talent, and liking for massage, united with soft, elastic, and strong hands, and physical endurance to use them, may be as useful artists in this department of the healing art as in others. It has been well said that those who do massage should be tender and gentle, yet strong and enduring. These are qualities that are rarely found combined in manipulators. It is a very common mistake to suppose that those who are of a remarkably healthy, ruddy appearance, plethoric and fat, are the best fitted to do massage. Such people require a great deal of exercise in the open air for the proper oxygenation of their blood, and confining, in-door work, like massage, they soon find to be tedious and irksome. Besides, the stooping attitude and varying positions so often necessary while doing this sort of work soon put them out of breath; and thus, while suffering from their ignorance and awkwardness, they fancy they are imparting "magnetism" to their patients at their own expense. Better that the manipulators should be rather thin, though if of too spare a habit their hands will not be sufficiently strong and muscular and their tissues generally will lack that firmness necessary for prolonged endurance.

One of the best German medical reviews, "Schmidt's Jahrbücher," in an extensive report on massage, thus indicates the esteem in which this treatment is held by many eminent physicians and surgeons of Europe: "It is but recently that massage has gained an extensive scientific consideration, since it has passed out of the hands of rough and ignorant empirics into those of educated physicians; and upon the results of recent scientific investigations it has been cultivated into an improved therapeutical system, and has won for itself in its entirety the merit of having become a special branch of the art of medicine." Professor Billroth, one of the most eminent surgeons of

Germany, in a lecture on this subject published in the "Wiener med. Wochen.," No. 45, 1875, says: "I can only agree with my colleagues, Langenbeck and Esmarch, that massage in suitable cases deserves more attention than has fallen to its lot in the course of the past ten years in Germany. . . . As practice in the manipulations, time, perseverance, and personal interest in the matter are necessary, and these one can not bestow who interests himself much in medicine and surgery, I have turned over to my old experienced surgical assistant suitable cases for massage, and he has already obtained a series of results both favorable and surprising, and far exceeding my expectations of this method of treatment." Previous to the past fifteen years the French physicians took more interest in massage than any others, but of late they have almost entirely laid it aside. With their waning interest the Scandinavians and Germans have taken up the subject with renewed zeal, and from time to time furnish instructive accounts of their experiments, successes, and failures.

How is massage regarded, and what is its condition, in the United States? Except among very few—epicures in this matter, if one may so speak—there is as yet but little evidence of a desire to place massage, and those who do it, on their merits alone, irrespective of the policy of employing persons who are only rubbing-machines, or of tolerating obnoxious individuals so long as the poor patients' minds are satisfied. This is too often the case, and then massage is said to have failed and valuable time is lost, when, if it had been properly applied, it might have been successful; or, on the other hand, perhaps it should have been omitted and other remedies employed. The writer of this, in a recent paper on the "History of Massage," has said: "In almost every city of the United States, and indeed of the whole civilized world, there may be found individuals claiming mysterious and magical powers of curing disease, setting bones, and relieving pain by the immediate application of their hands. Some of these boldly assert that their art is a gift from Heaven, due to some unknown power which they call magnetism, while others designate it by some peculiar word ending with *pathy* or *cure*, and it is astonishing how much credit they get for their supposed genius by many of the most learned people." Let a fisherman forsake his boat, or a blacksmith his anvil, or a carpenter his bench, or a shoe-maker his shop, and proclaim that he has made the wonderful discovery that he is full of magnetism and can cure all diseases, and, be he ever so ignorant and uncouth, he is likely to have, in a remarkably short space of time, a large *clientèle* of educated gentlemen and refined ladies. It is not meant to imply that the previous occupation of such people is at all to their discredit, but, were they capable of giving a rational explanation of their doings, the halo of mystery would be removed from around them, and their prestige and patronage would suffer a sudden decline.

In Boston and Philadelphia, and perhaps in other cities as well,

efforts have been made by physicians, who are thoroughly familiar with massage, to instruct intelligent nurses and others how to apply it, and at the training-schools for nurses the pupils receive some general instruction in the matter. In this way something has been accomplished to bring massage within the rules and regulations of common sense and rational therapeutics. But still there is great room for improvement even in this direction, for it is but too often the case that after one or two persons are specially trained to do massage they are requested to give instruction to some of the pupils at the schools for nurses, and to others, a few of whom, after having received some general desultory lessons, are in turn delegated or relegated to teach others, and so on, until, by the time massage reaches the needy patients, there is often little left of it but the name. Hence it is not to be wondered at that many a shrewd, superannuated auntie, and others who are out of a job, having learned the meaning of the word massage, immediately have it printed on their cards, and keep on with their "rubbin'" just as they always have done.

The vaguest generalities exist as to the manner of doing massage, even among the best authors on the subject, and, after having studied and tried the methods of all, the writer proposes to briefly formulate, as much as space will permit of, what he has found to be of value, without having adopted the methods of any in particular. By so doing it is hoped that some will be able to judge whether those employed to do massage know anything about it or not, or whether it would not be as well to employ one of their own domestics for ordinary rubbing, the advantages of which are not to be despised. At any rate, from the description which follows, I trust that not a few intelligent friends of chronic invalids, who are beyond the reach of the professional manipulator, will be enabled to apply massage so as to afford even greater relief and comfort than can be gained from many of those whom the ignorance of the community on this subject alone tolerates as experts.

The multiform subdivisions under which the various procedures of massage have been described can all be grouped under four different heads, viz., friction, percussion, pressure, and movement. Malaxation, manipulation, deep-rubbing, kneading, or massage, properly so called, is to be considered as a combination of the last two. Each and all of these may be gentle, moderate, or vigorous, according to the requirements of the case and the physical qualities of the operators. Some general remarks here will save repetition: 1. All of the single or combined procedures should be begun moderately, gradually increased in force and frequency to their fullest extent desirable, and should end gradually as begun. 2. The greatest extent of surface of the fingers and hands of the operator consistent with ease and efficacy of movement should be adapted to the surface worked upon, in order that no time be lost by working with the ends of the fingers or one

portion of the hands when all the rest might be occupied. 3. The patient should be placed in as easy and comfortable a position as possible, in a well-ventilated room at a temperature of about 70° Fahr. 4. What constitutes the dose of massage is to be determined by the force and frequency of the manipulations and the length of time during which they are employed. A good manipulator will do more in fifteen minutes than a poor one will in an hour, just as an old machanic working deliberately will accomplish more than an inexperienced one working furiously. Friction has been described as rectilinear, vertical, transverse or horizontal, and circular. It has been stated, and very properly, that rectilinear friction should always be used in an upward direction, from the extremities to the trunk, so as to favor and not retard the venous and lymphatic currents. But a slight deviation from this method I have found to be more advantageous, for though in almost every case the upward strokes of the friction should be the stronger, yet the returning or downward movement may with benefit lightly graze the surface, imparting a soothing influence, without being so vigorous as to retard the circulation, and thus a saving of time and effort will be gained. The manner in which a carpenter uses his plane represents this forward-and-return movement very well. Transverse friction, or friction at right angles to the long axis of a limb, is a very ungraceful and awkward procedure. It has been introduced on theoretical considerations alone, and may with safety be laid aside, for the method already spoken of, together with circular friction, will do all and a great deal more than rubbing crosswise on a limb can do. A convenient extent of territory, to begin with, is from the ends of the fingers to the wrist, each stroke being of this length, the returning stroke being light, without raising the hand. The rapidity of these double strokes may be from one hundred to one hundred and fifty a minute. The whole palmar surface of the fingers should be employed, and in such a manner that they will fit into the depressions formed by the approximation of the phalanges and metacarpal bones. The heel of the hand should be used for especially vigorous friction of the palm, as well as for the sole of the foot. From the wrist to the elbow, and from the elbow to the shoulder, are separately convenient extents of surface, and here not only straight-line friction, extending from one joint to the other, may be used, but also circular friction. The form of the latter which I have found most serviceable is in that of an oval, both hands moving at the same time, the one ascending as the other descends, at the rate of one hundred and twenty-five to two hundred and fifty each a minute, or two hundred and fifty to five hundred with both hands, each stroke reaching from joint to joint, the upward stroke being carefully kept within the limits of chafing the skin. These observations apply to the lower limbs also, but, as they are larger than the arms, the posterior and lateral aspects, from ankle to knee, will be a convenient

territory, while the anterior and lateral aspects will be another for thorough and efficacious friction. The same systematic division of surface may be made above the knees as below, the number of strokes below will vary from one hundred to one hundred and sixty with each hand; above, from seventy-five to one hundred each. From the base of the skull to the spine of the scapula forms another region naturally well bounded for downward and outward semicircular friction, and from the spine of the scapula to the base of the sacrum and crest of the ilium forms another surface over which one hand can sweep, while the other works toward it from the insertion to the origin of the glutei, at an average rate of sixty or seventy-five a minute with each hand for a person of medium size. It will be observed that on the back and thighs the strokes are not so rapid as on the other parts mentioned, for the reason that the skin is here thicker and coarser, in consequence of which the hand can not glide so easily, and the larger muscles beneath can well bear stronger pressure; besides, the strokes are somewhat longer, all of which require an increased expenditure of time. The chest should be done from the insertion to the origin of the pectoral muscles, and the abdomen from the right iliac fossa in the direction of the ascending, transverse and descending colon. But here friction is seldom necessary, for the procedure about to be considered accomplishes all that friction can do, and a great deal more in this region. The force used in doing friction is often much greater than is necessary, for it is only intended to act upon the skin, and there are better ways of acting upon the tissues beneath it. If redness and irritation be looked upon as a measure of the beneficial effects of friction upon the skin, then a coarse towel, a hair mitten, or a brush would answer for this purpose a great deal better than the hand alone.

The most important, agreeable, and efficacious procedure of massage has been variously designated as manipulation, kneading, deep-rubbing, or massage properly so called, in contradistinction to the more superficial method spoken of above. This is done by adapting as much as possible of the fingers and hands to the parts to be thus treated, and, without allowing them to slip on the skin, the tissues beneath are kneaded, rolled, and manipulated in a circulatory manner, proceeding from the insertion toward the origin of the muscles, from the extremities to the trunk, in the direction of the returning blood and lymphatic currents. For this purpose the same divisions of surface as for friction will be found most convenient. Beginning then with the fingers from the roots of the nails, the thumb of the manipulator will be placed on one of the fingers of the patient, and parallel to the latter, while on the opposite side the index-finger will be placed at right angles to this, and between the two the finger of the patient will be compressed and malaxated, in a rotary manner, at the rate of seventy-five to one hundred and fifty per minute. The dorsal and palmar surfaces will of course receive special attention, while the

lateral aspects will come in for a secondary share. If the manipulator be sufficiently expert he can work with both hands on this small surface with the same rapidity as with one. Each finger and thumb will be taken in turn, and the manipulations extended over the metacarpal and carpal bones as far as the wrist-joint, and finally the palm of the hand by stretching the tissues vigorously away from the median line. Each part included in a single grasp may receive three or four manipulations before proceeding onward to the adjacent region. The advance upon this should be such as to allow the finger and thumb to overlap one half of what has just been worked upon. Advance and review should thus be systematically carried on, and this is of general application to all the other tissues that can be *masséed.* The force used here and elsewhere must be carefully graduated so as to allow the patient's tissues to glide freely upon each other; for, if too great, the movement will be frustrated by the compression and perhaps bruising of the tissues; if too light, the operator's fingers will slip; and, if gliding with strong compression be used, the skin will be chafed. To avoid this last objection various greasy substances have been employed, so that ignorant would-be masseurs may rub without injuring the skin. When the skin is cold and dry, and the tissues in general are insufficiently nourished, as well as in certain fevers and other morbid conditions, there can be no doubt of the value of inunction; but no special skill is required in order to do this, and there is no need of calling it massage unless it be to please the fancy of the patient.

The feet may be dealt with in the same manner as the hands, using the ends of the fingers to work longitudinally between the metatarsal as well as between the metacarpal bones. Upon the arms and legs, and indeed upon all the rest of the body, both hands can be used to better advantage than where the surfaces are small. Each group of muscles should be systematically worked upon, and for this purpose one hand can usually be placed opposite to the other and in advance of it, so that two groups of muscles may be manipulated at the same time. When the circumference of the limb is not great, the fingers of one hand will partly reach on to the territory of the other, while grasping, circulatory, spiral manipulations are made, one hand contracting as the other relaxes, the greatest extension of the tissues being upward and laterally, and on the fore-arms and legs away from the median line. Subcutaneous bony surfaces, as those of the tibia and ulna, incidentally get sufficient attention while manipulating their adjacent muscles, for, if both be included in a vigorous grasp, unnecessary discomfort results. Care should be taken not to place the fingers and thumb of one hand too near those of the other, for by so doing their movements would be cramped. The elasticity, or want of it, in the patient's tissues, should be the guide, the object being to obtain their normal stretch, and in this every person is a law to himself, the character of their tissues varying with the amount and quality of

adipose, modes of life, exercise, etc. A frequent error on the part of manipulators is in attempting to stretch the tissues in opposite directions at the same time, especially at the flexures of the joints, where the skin is delicate and sensitive, and where the temptation to such procedures is greatest because easiest, the effect being a sensation of tearing of the skin. The rate of these manœuvres varies from seventy-five to one hundred and fifty with each hand per minute on the arms, from sixty to ninety on the legs, and from forty to eighty on the thighs, where more force is required on account of the larger size and density of the muscles, and the need of using sufficient force to extend beneath the strong, tense fascia lata.

On the back the direction of these efforts will be from the base of the skull downward, stretching the tissues away from the spinal column while manipulating in graceful curves at an average rate of sixty per minute with each hand. And here one hand can often be re-enforced by placing the other upon it, and thus massage may be done with all the strength the manipulator can put forth. With the ends of the fingers the muscles on each side of the spinal column can be rolled, and the supra-spinous ligament can be effectually *masséed* by transverse to-and-fro movements. The ends of the fingers and part of their palmar surface should also be placed on each side of the spinous processes, and the tissues situated between these and the transverse processes worked upon by up-and-down motions parallel to the spine, taking care to avoid the too frequent error of making pushing, jerky movements in place of smooth, uniform motions in each direction.

On the chest and abdomen the same general direction will be observed as in using friction, but the manipulation will be more gentle than on the back and limbs, for the tissues will not tolerate being so vigorously squeezed and pinched. Here the massage will consist of moderate pressure and movement with the palms of the hands, and rolling and grasping the skin and superficial fascia; and, after this, on the abdomen, steady, firm, deep kneading in the direction of the ascending, transverse, and descending colon, using for this purpose the greatest force with the heel of the hand on the side of the abdomen next the operator, and on the other side the strongest manipulations with the fingers, avoiding the frequent and disagreeable mistake of pressing at the same time on the anterior portions of the pelvis.

Before leaving this part of the subject, the writer begs leave to say something more about the common errors into which manipulators fall, even some of those who pass for being skillful. Many do not know how to do the kneading or malaxation with ease and comfort to themselves and to their patients, for, in place of working from their wrists and concentrating their energy in the muscles of their hands and fore-arms, they vigorously fix the muscles of their upper arms and shoulders, thus not only moving their own frame with every

manipulation, but also that of their patients, giving to the latter a motion and sensation as if they were at sea in stormy weather. By this display of awkward and unnecessary energy, not only do they soon tire themselves, and say that they have lost magnetism by imparting it to their patients, but by the too firm compression of the patient's tissues they are not allowed to glide over each other; and hence such a way of proceeding entirely fails of the object for which it is intended. Surely, cultivation is the economy of effort.

Friction and manipulation can be used alternately, varied with rapid pinching of the skin and deeper grasping of the subcutaneous cellular tissue and muscular masses, and, when necessary, with percussion, passive, assistive, and resistive movements, finishing one convenient surface or limb before passing to another, and occupying from half an hour to an hour with all or part of these procedures. Pinching is used mainly to excite the circulation and innervation of the skin, and for this purpose it is best done rapidly at the rate of one hundred to one hundred and twenty-five per minute with each hand. To act on the subcutaneous cellular tissue, a handful of skin is grasped and rolled and stretched more slowly than by the preceding method. A deeper, momentary grasping of the muscles is often advantageous, and may be called a *mobile intermittent compression*, and this, indeed, is what the whole of massage, strictly speaking, consists of. Percussion, applicable only over muscular masses, may be done in various ways. In the relative order of their importance they are as follows: 1. With the ulnar borders of the hands and fingers. 2. The same as the first, with the fingers separated. 3. With the ends of the fingers, the tips being united on the same plane. 4. With the dorsum of the upper halves of the fingers loosely flexed. 5. With the palms of the hands. 6. With the ulnar borders of the hands tightly shut. 7. With the palms of the hands held in a concave manner, so as to compress the air while percussing. More gentle or vigorous and rapid percussion than any of these methods afford can be done by securing India-rubber air-balls on whale-bone or steel handles. With these one gets the spring of the handles together with the rebound of the balls, and thus rapidity of motion with easily varying intensity is gained, the number of blows varying from two hundred and fifty to six hundred a minute with both.

Remedial movements have been so well described in books on the so-called "movement-cure" that little need be said of them here. It is well for those who use them to know the anatomy and physiology of the joints and their natural limits of motion. Except in the case of relaxed joints, passive motion should be pushed until there is a feeling of slight resistance to both patient and manipulator; for by this will be known that in healthy joints the ligaments, capsules, and attachments of the muscles are being acted upon. Resistive movements are such as the patient can make while the operator resists. The opposing

force should be carefully and instinctively kept within the limits of the patient's strength, and this, with all these other manœuvres, should stop short of fatigue. To alternately resist flexion and extension is the *pons asinorum* of manipulators, and, in a considerable experience of teaching massage, I have found but few who could learn to do it at all. Its importance can not be overestimated as a means of cultivating the strength of weakened muscles, while, at the same time, finding out how much they can be used. Many a patient who has recovered from an old injury is still as much incapacitated as ever, from the fact that his latent energies can only be discovered and made available in this manner. Midway between passive and resistive movements, in the course of certain recoveries, stand assistive movements. They are but little understood and seldom used. They may be illustrated as follows: Let it be supposed that, in the absence of adhesions and irreparable injury of the nerve-centers, the deltoid has but half the strength requisite to elevate the arm. So far as any use is concerned this is the same as if there were no power of contraction left in the muscle. But, if only the other half of the impaired vigor be supplemented by the carefully graduated assistance of the operator, the required movement will take place; and, in some cases, if this be regularly persisted in, together with manipulation and percussion, more vigorous contraction will be gained, and, by-and-by, the patient will exert three fourths of the necessary strength, and later the whole movement will be done without aid; and, as strength increases, resistance can be opposed to the movement. Partial loss of motion can often be accurately estimated by holding the limb suspended in a cloth attached to a spring-balance. When the patient makes effort the limb weighs less. By means of a spring-balance resistive motion can also be estimated. Still another kind of movement may be spoken of—namely, vigorous passive motion—with a view to breaking up adhesions in and about joints, a description of which does not come within the scope of this paper. It is the secret of success and of failure of the people who call themselves "bone-setters," the methods of whom have been well studied and explained by Dr. Wharton P. Hood, of London, in his very interesting book "On Bone-Setting, so called."

A description of massage of the head and the benefits that arise from it must be left to another time.

The relative importance of the foregoing procedures has been partly indicated while describing them. According to the needs of individual cases, one or more of these will predominate or be omitted, and it is well that the advice of a physician be sought on this subject, for there would be no use in giving a patient friction the capillary circulation of whose skin was already sufficiently good; and it would be a waste of time and strength to administer passive and resistive movements to patients who were already fatigued from overwork. To rouse the dormant action of cold skin and flabby muscle, percussion will be

of the first importance, and will alternate with friction and manipulation. Percussion is in massage what faradization is in electricity, and will often answer the same purpose; manipulation, or deep-kneading, is to massage what the constant current is to electricity, and the ultimate effects of each are very much alike. In "Schmidt's Jahrbücher" and elsewhere numerous instances are given in which massage has succeeded, after electricity and other means had failed. The reverse of this may be true, but as yet I have not seen any proof of it. Let us now speak of the general effects of massage, and, further on, its influence more in detail. And, first, it may be well to premise that it requires, on the part of the patient a certain amount of latent energy, if one may so call it, in order to undergo even a minimum *séance* of massage; for a patient may be so weak as to preclude the possibility of its being applied without harm resulting. In properly selected cases, instances of which are frequently seen in individuals suffering from overwork, or want of work, worry, depression of spirits, and loss of sleep, together with feeble and tardy digestion—those who can not get or take rest, no matter how favorable the opportunity—the effects of massage are generally as follows: While it is being done, and often for several hours afterward, the patients are in a blissful state of repose; they feel as if they were enjoying a long rest, or had just returned from a refreshing vacation, and not a few say that it makes optimists of them for the time being. It produces warmth, comfort, and sleep; relieves or cures constipation, muscular pains, and stiffness. At the same time it exerts a peculiarly delightful and profound effect upon the nervous system, its influence being tonic, sedative, and physiologically counter-irritant, making more blood flow through the skin and muscles, and consequently less to the brain, spinal cord, and internal organs. To those to whom exercise would be injurious, massage affords the advantages of exercise without exertion while the subjects of it are resting, their over-taxed will and used-up nervous energy not being required to express themselves in voluntary motion. For reasons such as these, we find no less an authority than the British "Journal of Mental Sciences" (for April, 1878) recommending "massage for certain melancholics, with trophic and vaso-motor affections, and also where dementia is threatened after an attack of excitement. Under this treatment mental comfort and a sense of well-being take the place of apathy and lassitude."

Lord Bacon has quaintly remarked that "repair is procured by nourishment, and nourishment is promoted by forwarding internal *concoction*, which drives forth the nourishment, as by medicines that invigorate the principal viscera; and, secondly, by exciting the external parts to attract the nourishment, as by exercise, proper frictions, etc." Massage excites the external parts to attract and assimilate the nourishment, brought thither by an increased volume of blood, and this, at the same time, favors absorption of the natural worn-out

débris. The different ranks of the Sandwich-Islanders are of different stature; and we are told that the chiefs, though sunk in sloth and immorality, are not diminutive and decrepit, like many of their countrymen, for the reason that they fare sumptuously, take little or no exercise, and are *lomi-lomied* after every meal, in order to aid their digestion and promote their circulation without inducing fatigue or exhaustion. *Lomi-lomi* is thus interestingly described by Nordhoff, in his book on "Northern California, Oregon, and the Sandwich Islands": "Wherever you stop, for lunch or for the night, if there are native people near, you will be greatly refreshed by the application of *lomi-lomi.* Almost everywhere you will find some one skilled in this peculiar, and, to tired muscles, delightful and refreshing treatment. To be *lomi-lomied,* you lie down upon a mat, or undress for the night, if you prefer. The less clothing you have on the more perfectly the operation can be performed. To you, thereupon, comes a stout native, with soft, fleshy hands, but a strong grip, and beginning with your head, and working down slowly over the whole body, seizes and squeezes with a quite peculiar art every tired muscle, working and kneading with indefatigable patience, until, in half an hour, whereas you were weary and worn out, you find yourself fresh, all soreness and weariness absolutely and entirely gone, and mind and body soothed to a healthful and refreshing sleep. The *lomi-lomi* is used not only by the natives, but among almost all the foreign residents; and not merely to procure relief from weariness, consequent upon over-exertion, but to cure headaches, to relieve the aching of neuralgic or rheumatic pains, and, by the luxurious, as one of the pleasures of life. I have known it to relieve violent headache in a very short time. The chiefs used to keep skillful *lomi-lomi* men in their retinues; and the late king, who was for some years too stout to take exercise, and was yet a gross feeder, had himself *lomi-lomied* after every meal, as a means of aiding his digestion. It is a device for relieving pain and weariness which seems to have no injurious reaction, and no drawback but one—it is said to fatten the subjects of it."

Dr. Weir Mitchell has successfully proved that many chronic invalids can be cured by rest and excessive feeding, made possible by means of massage and electricity. Under this combination of treatment, skillfully carried out, many become fat, strong, and well, thus illustrating the truth of Lord Bacon's remark, and the beneficial effects of the not very scientific massage of the Sandwich-Islanders. The *lomi-lomi* of the Sandwich-Islanders is only a series of intermittent squeezes proceeding toward the extremities, thus hindering the returning circulation; and this illustrates another fact—that many who have had but one kind of pinching and squeezing think it is "excellent" until they try some one who understands and can do it better; moreover, it shows that any sort of stirring up of the tissues is often better than none. In using massage, as much depends on the qualities and

qualifications of the person who does it as in any other occupation. It would be wrong to leave the impression that massage is always agreeable from the first. In proportion as the muscles, superficial fascia, and skin are unnaturally tough, tense, *matted* and *hide-bound*, will the massage be disagreeable until they become soft, supple, and elastic. An appreciation of the proper consistence of the tissues and their anatomical structure is of the utmost importance for the success of this treatment.

But we must hasten to consider how massage acts locally. By upward and oval friction, with deep manipulation, the veins and lymphatics are mechanically emptied—the blood and lymph are pushed along more quickly by the additional *vis a tergo* of the massage, and these fluids can not return by reason of the valvular folds on the internal coats of their vessels. Thus, not only is more space created for the returning currents arising from beyond the region *masséed*, but, at the same time, a vacuum is formed, which is visible in the superficial veins of persons who are not too fat; and this is thought by some to add a new force to the more distal circulation. In this way the collateral circulation in the deeper vessels is aided and relieved, as well as the more distal stream in the capillaries and arterioles. One would naturally suppose that the circulation in the larger arteries would, in this manner, be interrupted, and such is the case. But, herein comes an additional advantage to aid the circulation, for the temporary and momentary intermittent compression causes a dilatation of the artery from an increased volume of blood above the part pressed upon, and this accumulation rushes onward with greater rapidity as soon as the pressure is removed, in consequence of the force of the heart's action and the resiliency of the arteries acting upon the accumulated volume of blood.

But the same pressure also acts upon the tissues external to the vessels, causing a more rapid resorption of natural or pathological products through the walls of the venous capillaries and lymphatics. When muscular nerves are stimulated, the vaso-dilators are influenced, and this takes place by massage, whence follows enlargement of the lumen of the vessels, so that an increased flow passes through them with greater ease and diminished pressure. When stimuli are applied to the skin, reflex vaso-motor action shows that the vaso-dilators are acted upon, hence the redness and congestion of the skin when massage is specially directed to it. It can be readily seen now that massage rouses dormant capillaries, increases the area and speed of the circulation, furthers absorption and stimulates the vaso-motor nerves, all of which are aids and not hindrances to the heart's action, as well as to nutrition in general. Seeing that more blood passes in a given time, there will be an increase in the total interchange between the blood and the tissues, and thus the total amount of work done by the circulation will be greater and the share borne by each quantity of

blood less. It will not be surprising, then, to learn that in practice massage sometimes proves a valuable ally in the treatment of functional and organic diseases of the heart, for "the peripheral friction of the blood against the walls of the capillaries and small arteries not only opposes the flow of blood through them, but, working backward along the whole arterial system, has to be overcome by the heart at each systole of the left ventricle." This obstacle is in great part lessened by massage. In exercise there is alternate contraction and relaxation of voluntary muscles, and this is a powerful aid to the circulation in general; for at each contraction the vessels are emptied by compression, and the alternating relaxation allows them to fill up again. Thus each muscle or group of muscles in activity has been appropriately likened to a beating heart. In this respect the intermittent pressure of massage aids and imitates the alternate contraction and relaxation of muscles very accurately, and no better praise could be bestowed upon any therapeutical agent than the old-fashioned, haughty, supercilious way of dismissing the subject of massage as unworthy of notice by saying that it was merely a substitute for exercise. Exercise favors all the functions, and people who can exercise freely without fatigue, and who can eat and sleep well, seldom need massage. I am aware that this statement includes many neurasthenics, especially those who suffer from want of occupation.

While undergoing massage it is well for the patient to take frequent and deep inspirations, in order to favor the flow of the venous and lymphatic currents to the thorax. This, however, is often instinctively done, and with such ease that the patient feels as if freed from an immense load. From a paper by Professor H. P. Bowditch, in the "Proceedings of the American Academy of Arts and Sciences," for 1873, "On the Lymph-Spaces in Fasciæ," we learn the following valuable and interesting facts: "In experiments on animals where the flow of lymph through the thoracic duct was measured, passive movements of the limbs increased this flow in a remarkable manner. Galvanization of the muscles had a similar but less powerful effect. The lymph-spaces existing between the tendinous fibers of fasciæ and the connection of these spaces with lymphatic vessels have been described by Ludwig and others. By virtue of this structure the fasciæ play an important part in keeping up the flow of lymph through the lymphatic vessels. A piece of fascia was removed from the leg of a dog and tied over the mouth of a glass funnel, with the side next the muscles uppermost. A few drops of a colored turpentine solution were then placed upon this surface, and the fascia alternately stretched and relaxed by partially exhausting the air from the funnel and allowing it to return again. In this way the coloring matter was made to penetrate into the spaces between the fibers of the fascia and to enter the lymph-spaces on the opposite side. The same result was obtained when the coloring matter was injected between the muscles and the

fascia, and the latter stretched and relaxed by passive movements of the limb. The alternate widening and narrowing of the lymph-spaces between the tendinous fibers seems, therefore, to cause absorption of the lymph from the neighboring parts as well as its onward flow into the lymphatic vessels." This function of the fascia certainly affords a partial, important, and, so far as it goes, very satisfactory explanation of the success of methods of treatment which involve passive motion, for the removal of effete matters from the tissues is favored by an increased flow of lymph.

But Nature, as one of her regular functions, is continually performing this experiment in the voluntary and involuntary movements of the muscles. The large serous cavities, such as those of the pleura and peritonæum, are now regarded as extensive lacunæ in the course of the lymphatic vessels; lymph-spaces and lymphatic vessels, communicating with each other by means of small openings or stomata, have been demonstrated in these membranes, and also the communication of the lymph-spaces with the pleural and peritoneal cavities by means of intercellular openings. This has been shown by injecting either of these cavities with colored fluid, and, after killing the animal, examining the course of absorption of the fluid under the microscope. In the movements of respiration, alternate expansion and contraction of the chest-walls, with descent and ascent of the diaphragm, we have a continual pump-like action of absorption and onward expulsion in the lymph-spaces and lymphatic vessels of the pleura and peritonæum. But we must not forget that the capillary blood-vessels are similarly influenced, nor should we fail to remember that osmosis may also play a very important part, and that this, too, can be increased by artificial pressure. We can now understand why the kings of the Sandwich Islands should be *lomi-lomied* after every meal in order to aid their digestion, for the externally applied pressure over the abdomen would force the contents of the lacteals, or lymphatics of the small intestine, onward, at the same time aiding them in their absorption of digestive products.

Professor von Mosengeil, of Bonn, has made some interesting and useful experiments by injecting the cavities of corresponding joints of rabbits with Indian ink, and in this way proving that resorption takes place from these cavities by means of lymph-spaces and stomata, communicating with lymphatic vessels, and through these with lymphatic glands. With each rabbit he *masséed* one of the joints and left the corresponding joint untouched. The swelling that arose from the injection always disappeared rapidly under massage, and, upon examination of the *masséed* joint, it was found emptied for the most part of its colored contents. Even when the examination was made shortly after the injection and the use of massage, there was proportionately little ink found in the joint, part of it was found upon the synovial membrane; and upon microscopic examination it was seen that the

greatest part had been forced into, and had penetrated through, the synovial membrane, and the darkened lymphatics could be seen with the unaided eye from the injected joint to the lymphatic glands, and these latter were black from the absorption of the ink. Upon examination of the injected joint-cavities that had not been *masséed*, the ink was still found in the joint mixed with the synovia in a smeary mass, and it had not even penetrated into the tissue of the synovial membrane. With the removal of the effusion by the use of massage, Von Mosengeil always succeeded in improving the stiffness, and in obtaining the same appearances in the lymphatics.

From clinical experience in the use of massage in joint affections, such results as those obtained by Von Mosengeil might have been with safety predicted. A consideration of the mode of application of massage in joint injuries and affections, and its relations to mechanical support, rest, and exercise, would far exceed the limits of this paper. Scandinavian, German, and French army-surgeons, who with their own hands have used massage the most in joint maladies, have accumulated respectable and trustworthy statistics showing its great value in such cases. At the same time they have not forgotten to tabulate their failures. The result of their experience in recent joint injuries admitting of the application of massage is thus formulated: "*It will simultaneously further and increase resorption, accelerate the circulation, relieve pain, and reduce elevated temperature.*" I have illustrated this by a report of over three hundred cases, the details of which may be found in the "New York Medical Record," No. 353. The "Nouveau Dictionnaire de Médecine" clearly expresses the action of massage in the following words: "Massage augments interstitial absorption not only by the *sur-activité* impressed upon the returning circulation, but also by dividing to infinity pathological and normal products accumulated in the muscular interstices and meshes of the cellular tissue. The dissemination of these products multiplies their points of contact with the walls of the veins and lymphatics, whence result their imbibition and diffusion into the general circulation."

But, discuss any therapeutical agent as we may, there is something still peculiar to each that evades expression by tongue or pen. Of what use is it to describe odors, tastes, sensations, sights, and sounds? They can only be comprehended by smelling, tasting, feeling, seeing, and hearing. Just so with the peculiar calm, soothing, restful, light feeling that so often results from massage, which can not be understood until experienced. It doubtless arises to a great extent from the pressure of natural worn-out *débris* being speedily removed from off terminal nerve-filaments. Furthermore, massage excites and awakens the *muscular sense* in an agreeable and beneficial manner such as nothing else does, and we know that the state of our muscles indicates and often determines our feeling of health and vigor, or of

weariness and feebleness. To many minds a more satisfactory way of explaining the phenomena produced by massage would be by saying that they all occur in consequence of "magnetism," by which they have an indefinite understanding that this is some sort of imperceptible, ethereal fluid passing from one person to another. Such an explanation is low, gross, and vulgar, and it is erroneously used as a synonym for personal influence by people who do not know the proper scientific meaning of magnetism. Those who claim to have a vast stock of "magnetism" are like those who talk much of their bravery —sensible people find them devoid of either.

LITERATURE AND SCIENCE.*

By MATTHEW ARNOLD.

"NO wisdom, nor counsel, nor understanding, against the Eternal!" says the Wise Man. Against the natural and appointed course of things there is no contending. Ten years ago I remarked on the gloomy prospect for letters in this country, inasmuch as while the aristocratic class, according to a famous dictum of Lord Beaconsfield, was totally indifferent to letters, the friends of physical science, on the other hand, a growing and popular body, were in active revolt against them. To deprive letters of the too great place they had hitherto filled in men's estimation, and to substitute other studies for them, was now the object, I observed, of a sort of crusade with the friends of physical science—a busy host, important in itself, important because of the gifted leaders who march at its head, important from its strong and increasing hold upon public favor.

I could not help, I then went on to say, I could not help being moved with a desire to plead with the friends of physical science on behalf of letters, and in deprecation of the slight which they put upon them. But from giving effect to this desire I was at that time drawn off by more pressing matters. Ten years have passed, and the prospects of any pleader for letters have certainly not mended. If the friends of physical science were in the morning sunshine of popular favor even then, they stand now in its meridian radiance. Sir Josiah Mason founds a college at Birmingham to exclude "mere literary instruction and education"; and at its opening a brilliant and charming debater, Professor Huxley, is brought down to pronounce their funeral oration. Mr. Bright, in his zeal for the United States, exhorts young people to drink deep of "Hiawatha"; and the "Times"—which takes the gloomiest view possible of the future of letters, and thinks that

* Address delivered as "The Rede Lecture" at Cambridge.

a hundred years hence there will only be a few eccentrics reading letters, and almost every one will be studying the natural sciences—the "Times," instead of counseling Mr. Bright's young people rather to drink deep of Homer, is for giving them, above all, "the works of Darwin and Lyell and Bell and Huxley," and for nourishing them upon the voyage of the Challenger. Stranger still, a brilliant man of letters in France, M. Renan, assigns the same date of a hundred years hence as the date by which the historical and critical studies, in which his life has been passed and his reputation made, will have fallen into neglect, and deservedly so fallen. It is the regret of his life, M. Renan tells us, that he did not himself originally pursue the natural sciences, in which he might have forestalled Darwin in his discoveries.

What does it avail, in presence of all this, that we find one of your own prophets, Bishop Thirlwall, telling his brother who was sending a son to be educated abroad that he might be out of the way of Latin and Greek, "I do not think that the most perfect knowledge of every language now spoken under the sun could compensate for the want of them"? What does it avail, even, that an august lover of science, the great Goethe, should have said, "I wish all success to those who are for preserving to the literature of Greece and Rome its predominant place in education"? Goethe was a wise man, but the irresistible current of things was not then manifest as it is now. "No wisdom, nor counsel, nor understanding, against the Eternal!"

But to resign one's self too passively to supposed designs of the Eternal is fatalism. Perhaps they are not really designs of the Eternal at all, but designs—let us for example say—of Mr. Herbert Spencer. Still the design of abasing what is called "mere literary instruction and education," and of exalting what is called "sound, extensive, and practical scientific knowledge," is a very positive design and makes great progress. The universities are by no means outside its scope. At the recent congress in Sheffield of elementary teachers—a very able and important body of men whose movements I naturally follow with strong interest—at Sheffield one of the principal speakers proposed that the elementary teachers and the universities should come together on the common ground of natural science. On the ground of the dead languages, he said, they could not possibly come together; but, if the universities would take natural science for their chosen and chief ground instead, they easily might. Mohammed was to go to the mountain, as there was no chance of the mountain's being able to go to Mohammed.

The vice-chancellor has done me the honor to invite me to address you here to-day, although I am not a member of this great university. Your liberally conceived use of Sir Robert Rede's lecture leaves you free in the choice of a person to deliver the lecture founded by him, and on the present occasion the vice-chancellor has gone for a lecturer

to the sister university. I will venture to say that to an honor of this kind from the University of Cambridge no one on earth can be so sensible as a member of the University of Oxford. The two universities are unlike anything else in the world, and they are very like one another. Neither of them is inclined to go hastily into raptures over her own living offspring or over her sister's; each of them is peculiarly sensitive to the good opinion of the other. Nevertheless they have their points of dissimilarity. One such point, in particular, can not fail to arrest notice. Both universities have told powerfully upon the mind and life of the nation. But the University of Oxford, of which I am a member, and to which I am deeply and affectionally attached, has produced great men, indeed, but has, above all, been the source or the center of great movements. We will not now go back to the middle ages; we will keep within the range of what is called modern history. Within this range, we have the great movements of Royalism, Wesleyanism, Tractarianism, Ritualism, all of them having their source or their center in Oxford. You have nothing of the kind. The movement taking its name from Charles Simeon is far, far less considerable than the movement taking its name from John Wesley. The movement attempted by the Latitude men in the seventeenth century is next to nothing as a movement; the men are everything. And this is, in truth, your great, your surpassing distinction; not your movements, but your men. From Bacon to Byron, what a splendid roll of great names you can point to! We, at Oxford, can show nothing equal to it. Yours is the university not of great movements, but of great men. Our experience at Oxford disposes us, perhaps, to treat movements, whether our own, or extraneous movements such as the present movement for revolutionizing education, with too much respect. That disposition finds a corrective here. Masses make movements, individualities explode them. On mankind in the mass, a movement, once started, is apt to impose itself by routine; it is through the insight, the independence, the self-confidence of powerful single minds that its yoke is shaken off. In this university of great names, whoever wishes not to be demoralized by a movement comes into the right air for being stimulated to pluck up his courage and to examine what stuff movements are really made of.

Inspirited, then, by this tonic air in which I find myself speaking, I am boldly going to ask whether the present movement for ousting letters from their old predominance in education, and for transferring the predominance in education to the natural sciences, whether this brisk and flourishing movement ought to prevail, and whether it is likely that in the end it really will prevail. My own studies have been almost wholly in letters, and my visits to the field of the natural sciences have been very slight and inadequate, although those sciences strongly move my curiosity. A man of letters, it will perhaps be

said, is quite incompetent to discuss the comparative merits of letters and natural science as means of education. His incompetence, however, if he attempts the discussion but is really incompetent for it, will be abundantly visible; nobody will be taken in; he will have plenty of sharp observers and critics to save mankind from that danger. But the line I am going to follow is, as you will soon discover, so extremely simple that perhaps it may be followed without failure even by one who for a more ambitious line of discussion would be quite incompetent.

Some of you may have met with a phrase of mine which has been the object of a good deal of comment; an observation to the effect that in our culture, the aim being to know ourselves and the world, we have, as the means to this end, to know the best which has been thought and said in the world. Professor Huxley, in his discourse at the opening of Sir Josiah Mason's college, laying hold of this phrase, expanded it by quoting some more words of mine, which are these: "Europe is to be regarded as now being, for intellectual and spiritual purposes, one great confederation, bound to a joint action and working to a common result; and whose members have for their common outfit a knowledge of Greek, Roman, and Eastern antiquity, and of one another. Special local and temporary advantages being put out of account, that modern nation will, in the intellectual and spiritual sphere, make most progress which most thoroughly carries out this programme."

Now on my phrase, thus enlarged, Professor Huxley remarks that I assert literature to contain the materials which suffice for making us know ourselves and the world. But it is not by any means clear, says he, that, after having learned all which ancient and modern literatures have to tell us, we have laid a sufficiently broad and deep foundation for that criticism of life which constitutes culture. On the contrary, Professor Huxley declares that he finds himself "wholly unable to admit that either nations or individuals will really advance, if their common outfit draws nothing from the stores of physical science. An army without weapons of precision and with no particular base of operations might more hopefully enter upon a campaign on the Rhine than a man devoid of a knowledge of what physical science has done in the last century upon a criticism of life."

This shows how needful it is, for those who are to discuss a matter together, to have a common understanding as to the sense of the terms they employ—how needful, and how difficult. What Professor Huxley says implies just the reproach which is so often brought against the study of *belles-lettres*, as they are called: that the study is an elegant one, but slight and ineffectual; a smattering of Greek and Latin and other ornamental things, of little use for any one whose object is to get at truth. So, too, M. Renan talks of the "superficial humanism"

of a school-course which treats us as if we were all going to be poets, writers, orators, and he opposes this humanism to positive science, or the critical search after truth. And there is always a tendency, in those who are remonstrating against the predominance of letters in education, to understand by letters *belles-lettres*, and by *belles-lettres* a superficial humanism, the opposite of science or true knowledge.

But when we talk of knowing Greek and Roman antiquity, for instance, which is what people have called humanism, we mean a knowledge which is something more than a superficial humanism, mainly decorative. "I call all teaching *scientific*," says Wolf, the critic of Homer, "which is systematically laid out and followed up to its original sources. For example: a knowledge of classical antiquity is scientific when the remains of classical antiquity are correctly studied in the original languages." There can be no doubt that Wolf is perfectly right, that all learning is scientific which is systematically laid out and followed up to its original sources, and that a genuine humanism is scientific.

When I speak of knowing Greek and Roman antiquity, therefore, as a help to knowing ourselves and the world, I mean more than a knowledge of so much vocabulary, so much grammar, so many portions of authors, in the Greek and Latin languages. I mean knowing the Greeks and Romans, and their life and genius, and what they were and did in the world; what we get from them, and what is its value. That, at least, is the ideal; and, when we talk of endeavoring to know Greek and Roman antiquity as a help to knowing ourselves and the world, we mean endeavoring so to know them as to satisfy this ideal, however much we may still fall short of it.

The same as to knowing our own and other modern nations, with the aim of getting to understand ourselves and the world. To know the best that has been thought and said by the modern nations is to know, says Professor Huxley, "only what modern *literatures* have to tell us; it is the criticism of life contained in modern literature." And yet "the distinctive character of our times," he urges, "lies in the vast and constantly increasing part which is played by natural knowledge." And how, therefore, can a man, devoid of knowledge of what physical science has done in the last century, enter hopefully upon a criticism of modern life?

Let us, I say, be agreed about the meaning of the terms we are using. I talk of knowing the best which has been thought and uttered in the world; Professor Huxley says this means knowing *literature*. Literature is a large word; it may mean everything written with letters or printed in a book. Euclid's "Elements" and Newton's "Principia" are thus literature. All knowledge that reaches us through books is literature. But by literature Professor Huxley means *belles-lettres*. He means to make me say that knowing the best which has been thought and said by the modern nations is knowing their *belles-*

lettres and no more. And this is no sufficient equipment, he argues, for a criticism of modern life. But as I do not mean, by knowing ancient Rome, knowing merely more or less of Latin *belles-lettres*, and taking no account of Rome's military and political and legal and administrative work in the world; and as, by knowing ancient Greece, I understand knowing her as the giver of Greek art, and the guide to a free and right use of reason and to scientific method, and the founder of our mathematics and physics and astronomy and biology—I understand knowing her as all this, and not merely knowing certain Greek poems, histories, and speeches—so as to the knowledge of modern nations also. By knowing modern nations, I mean not merely knowing their *belles-lettres*, but knowing also what has been done by such men as Copernicus, Galileo, Newton, Darwin. "Our ancestors learned," says Professor Huxley, "that the earth is the center of the visible universe, and that man is the cynosure of things terrestrial; and more especially was it inculcated that the course of nature had no fixed order, but that it could be, and constantly was, altered." But for us now, says Professor Huxley, "the notions of the beginning and the end of the world entertained by our forefathers are no longer credible. It is very certain that the earth is not the chief body in the material universe, and that the world is not subordinated to man's use. It is even more certain that nature is the expression of a definite order, with which nothing interferes. . . . And yet," he cries, "the purely classical education advocated by the representatives of the humanists in our day gives no inkling of all this!"

In due place and time we will, perhaps, touch upon the question of classical education, but at present the question is as to what is meant by knowing the best which modern nations have thought and said. It is not knowing their *belles-lettres* merely that is meant. To know Italian *belles-lettres* is not to know Italy, and to know English *belles-lettres* is not to know England. Into knowing Italy and England there comes a great deal more, Galileo and Newton among it. The reproach of being a superficial humanism, a tincture of *belles-lettres*, may attach rightly enough to some other disciplines; but, to the particular discipline recommended when I proposed knowing the best that has been thought and said in the world, it does not apply. In that best I certainly include what in modern times has been thought and said by the great observers and knowers of nature.

There is, therefore, really no question between Professor Huxley and me as to whether knowing the results of the scientific study of nature is not required as a part of our culture, as well as knowing the products of literature and art. But to follow the processes by which those results are reached ought, say the friends of physical science, to be made the staple of education for the bulk of mankind. And here there does arise a question between those whom Professor Huxley calls with playful sarcasm "the Levites of culture" and those

whom the poor humanist is sometimes apt to regard as its Nebuchadnezzars.

The great results of the scientific investigation of nature we are agreed upon knowing, but how much of our study are we bound to give to the processes by which those results are reached? The results have their visible bearing on human life. But all the processes, too, all the items of fact, by which those results are established, are interesting. All knowledge is interesting to a wise man, and the knowledge of nature is interesting to all men. It is very interesting to know that from the albuminous white of the egg the chick in the egg gets the materials for its flesh, bones, blood, and feathers, while from the fatty yolk of the egg it gets the heat and energy which enable it at length to break its shell and begin the world. It is less interesting, perhaps, but still it is interesting, to know that, when a taper burns, the wax is converted into carbonic acid and water. Moreover, it is quite true that the habit of dealing with facts which is given by the study of nature is, as the friends of physical science praise it for being, an excellent discipline. The appeal is to observation and experiment; not only is it said that the thing is so, but we can be made to see that it is so. Not only does a man tell us that, when a taper burns, the wax is converted into carbonic acid and water, as a man may tell us, if he likes, that Charon is in his boat on the Styx, or that Victor Hugo is a truly great poet, but we are made to see that the conversion into carbonic acid and water does really happen. This reality of natural knowledge it is which makes the friends of physical science contrast it, as a knowledge of things, with the humanist's knowledge, which is, say they, a knowledge of words. And hence Professor Huxley is moved to lay it down that, "for the purpose of attaining real culture, an exclusively scientific education is at least as effectual as an exclusively literary education." And a certain president of the Section for Mechanical Science in the British Association is, in Scripture phrase, "very bold," and declares that, if a man, in his education, "has substituted literature and history for natural science, he has chosen the less useful alternative." Whether we go these lengths or not, we must all admit that in natural science the habit gained of dealing with facts is a most valuable discipline, and that every one should have some experience of it.

But it is proposed to make the training in natural science the main part of education, for the great majority of mankind at any rate. And here, I confess, I part company with the friends of physical science, with whom up to this point I have been agreeing. In differing from them, however, I wish to proceed with the utmost caution and diffidence. The smallness of my acquaintance with the disciplines of natural science is ever before my mind, and I am fearful of doing them injustice. The ability of the partisans of natural science makes them formidable persons to contradict. The tone of tentative

inquiry, which befits a being of dim faculties and bounded knowledge, is the tone I would wish to take and not to depart from. At present it seems to me that those who are for giving to natural knowledge, as they call it, the chief place in the education of the majority of mankind leave one important thing out of their account—the constitution of human nature. But I put this forward on the strength of some facts not at all recondite, very far from it; facts capable of being stated in the simplest possible fashion, and to which, if I so state them, the man of science will, I am sure, be willing to allow their due weight.

Deny the facts altogether, I think, he hardly can. He can hardly deny that, when we set ourselves to enumerate the powers which go to the building up of human life, and say that they are the power of conduct, the power of intellect and knowledge, the power of beauty, and the power of social life and manners—he can hardly deny that this scheme, though drawn in rough and plain lines, and not pretending to scientific exactness, does yet give a fairly true account of the matter. Human nature is built up by these powers; we have the need for them all. This is evident enough, and the friends of physical science will admit it. But, perhaps, they may not have sufficiently observed another thing, namely, that these powers just mentioned are not isolated, but there is in the generality of mankind a perpetual tendency to relate them one to another in divers ways. With one such way of relating them I am particularly concerned here. Following our instinct for intellect and knowledge, we acquire pieces of knowledge; and presently, in the generality of men, there arises the desire to relate these pieces of knowledge to our sense for conduct, to our sense for beauty, and there are weariness and dissatisfaction if the desire is balked. Now, in this desire lies, I think, the strength of that hold which letters have upon us.

All knowledge is, as I said just now, interesting; and even items of knowledge which from the nature of the case can not well be related, but must stand isolated in our thoughts, have their interest. Even lists of exceptions have their interest. If we are studying Greek accents, it is interesting to know that *pais* and *pas*, and some other monosyllables of the same form of declension, do not take the circumflex upon the last syllable of the genitive plural, but vary, in this respect, from the common rule. If we are studying physiology, it is interesting to know that the pulmonary artery carries dark blood, and the pulmonary vein carries bright blood, departing in this respect from the common rule for the division of labor between the veins and the arteries. But every one knows how we seek naturally to combine the pieces of our knowledge together, to bring them under general rules, to relate them to principles; and how unsatisfactory and tiresome it would be to go on for ever learning lists of exceptions, or accumulating items of fact which must stand isolated.

Well, that same need of relating our knowledge which operates here within the sphere of our knowledge itself, we shall find operating, also, outside that sphere. We feel, as we go on learning and knowing, the vast majority of mankind feel, the need of relating what we have learned and known to the sense which we have in us for conduct, to the sense which we have in us for beauty.

The prophetess Diotima explained to Socrates that love is, in fact, nothing but the desire in men that good should be for ever present to them. This primordial desire it is, I suppose—this desire in men that good should be for ever present to them—which causes in us the instinct for relating our knowledge to our sense for conduct and to our sense for beauty. At any rate, with men in general the instinct exists. Such is human nature. Such is human nature; and, in seeking to gratify the instinct, we are following the instinct of self-preservation in humanity.

Knowledges which can not be directly related to the sense for beauty, to the sense for conduct, are instrument-knowledges; they lead on to other knowledge, which can. A man who passes his life in instrument-knowledges is a specialist. They may be invaluable as instruments to something beyond, for those who have the gift thus to employ them; and they may be disciplines in themselves wherein it is useful to every one to have some schooling. But it is inconceivable that the generality of men should pass all their mental life with Greek accents or with formal logic. My friend Professor Sylvester, who holds transcendental doctrines as to the virtue of mathematics, is far away in America; and, therefore, if in the Cambridge Senate-House one may say such a thing without profaneness, I will hazard the opinion that, for the majority of mankind, a little mathematics, also, goes a long way. Of course, this is quite consistent with their being of immense importance as an instrument to something else; but it is the few who have the aptitude for thus using them, not the bulk of mankind.

The natural sciences do not stand on the same footing with these instrument-knowledges. Experience shows us that the generality of men will find more interest in learning that, when a taper burns, the wax is converted into carbonic acid and water, or in learning the explanation of the phenomenon of dew, or in learning how the circulation of the blood is carried on, than they find in learning that the genitive plural of *pais* and *pas* does not take the circumflex on the termination. And one piece of natural knowledge is added to another, and others to that, and at last we come to propositions so interesting as the proposition that "our ancestor was a hairy quadruped furnished with a tail and pointed ears, probably arboreal in his habits." Or we come to propositions of such reach and importance as those which Professor Huxley brings us, when he says that the notions of our forefathers about the beginning and the end of the world were all wrong,

and that nature is the expression of a definite order with which nothing interferes.

Interesting, indeed, these results of science are, important they are, and we should all be acquainted with them. But what I now wish you to mark is, that we are still, when they are propounded to us and we receive them, we are still in the sphere of intellect and knowledge. And for the generality of men there will be found, I say, to arise, when they have duly taken in the proposition that their ancestor was "a hairy quadruped furnished with a tail and pointed ears, probably arboreal in his habits," there will be found to arise an invincible desire to relate this proposition to the sense within them for conduct and to the sense for beauty. But this the men of science will not do for us, and will hardly, even, profess to do. They will give us other pieces of knowledge, other facts, about other animals and their ancestors, or about plants, or about stones, or about stars; and they may finally bring us to those "general conceptions of the universe which have been forced upon us," says Professor Huxley, "by physical science." But still it will be knowledge only which they give us; knowledge not put for us into relation with our sense for conduct, our sense for beauty, and touched with emotion by being so put; not thus put for us, and therefore, to the majority of mankind, after a certain while, unsatisfying, wearying.

Not to the born naturalist, I admit. But what do we mean by a born naturalist? We mean a man in whom the zeal for observing nature is so strong and eminent that it marks him off from the bulk of mankind. Such a man will pass his life happily in collecting natural knowledge and reasoning upon it, and will ask for nothing, or hardly anything, more. I have heard it said that the sagacious and admirable naturalist whom we have lately lost, Mr. Darwin, once owned to a friend that for his part he did not experience the necessity for two things which most men find so necessary to them—poetry and religion; science and the domestic affections, he thought, were enough. To a born naturalist, I can well understand that this should seem so. So absorbing is his occupation with nature, so strong his love for his occupation, that he goes on acquiring natural knowledge and reasoning upon it, and has little time or inclination for thinking about getting it related to the desire in man for conduct, the desire in man for beauty. He relates it to them for himself as he goes along, so far as he feels the need; and he draws from the domestic affections all the additional solace necessary. But then Darwins are very rare. Another great and admirable master of natural knowledge, Faraday, was a Sandemanian. That is to say, he related his knowledge to his instinct for conduct and to his instinct for beauty by the aid of that respectable Scottish sectary, Robert Sandeman. And, for one man among us with the disposition to do as Darwin did in this respect, there are fifty, probably, with the disposition to do as Faraday.

Professor Huxley holds up to scorn mediæval education, with its neglect of the knowledge of nature, its poverty of literary studies, its formal logic devoted to "showing how and why that which the Church said was true must be true." But the great mediæval universities were not brought into being, we may be sure, by the zeal for giving a jejune and contemptible education. Kings have been our nursing fathers, and queens have been our nursing mothers, but not for this. Our universities came into being because the supposed knowledge delivered by Scripture and the Church so deeply engaged men's hearts, and so simply, easily, and powerfully related itself to the desire for conduct, the desire for beauty—the general desire in men, as Diotima said, that good should be for ever present to them. All other knowledge was dominated by this supposed knowledge and was subordinated to it, because of the surpassing strength of the hold which it gained upon men's affections by allying itself profoundly with their sense for conduct and their sense for beauty.

But now, says Professor Huxley, conceptions of the universe fatal to the notions held by our forefathers have been forced upon us by physical science. Grant to him that they are thus fatal, that they must and will become current everywhere, and that every one will finally perceive them to be fatal to the beliefs of our forefathers. The need of humane letters, as they are truly called, because they serve the paramount desire in men that good should be for ever present to them—the need of humane letters to establish a relation between the new conceptions and our instinct for beauty, our instinct for conduct, is only the more visible. The middle age could do without humane letters, as it could do without the study of nature, because its supposed knowledge was made to engage its emotions so powerfully. Grant that the supposed knowledge disappears, its power of being made to engage the emotions will of course disappear along with it—but the emotions will remain. Now, if we find by experience that humane letters have an undeniable power of engaging the emotions, the importance of humane letters in man's training becomes not less, but greater, in proportion to the success of science in extirpating what it calls "mediæval thinking."

Have humane letters, have poetry and eloquence, the power here attributed to them of engaging the emotions, and how do they exercise it? and, if they have it and exercise it, how do they exercise it in relating the results of natural science to man's sense for conduct, his sense for beauty? All these questions may be asked. First, have poetry and eloquence the power of calling out the emotions? The appeal is to experience. Experience shows us that for the vast majority of men, for mankind in general, they have the power. Next, how do they exercise it? And this is perhaps a case for applying the Preacher's words: "Though a man labor to seek it out, yet he shall not find it; yea, further, though a wise man think to know it, yet

shall he not be able to find it." Why should it be one thing, in its effect upon the emotions, to say, "Patience is a virtue," and quite another thing, in its effect upon the emotions, to say with Homer,

τλητὸν γὰρ Μοῖραι θυμὸν θέσαν ἀνθρώποισιν *—

"for an enduring heart have the destinies appointed to the children of men"? Why should it be one thing, in its effect upon the emotions, to say with Spinoza, *Felicitas in eo consistit quod homo suum esse conservare potest*—"Man's happiness consists in his being able to preserve his own essence," and quite another thing, in its effect upon the emotions, to say, "What is a man advantaged, if he gain the whole world and lose himself, forfeit himself?" How does this difference of effect arise? I can not tell, and I am not much concerned to know; the important thing is that it does arise, and that we can profit by it. But how, finally, are poetry and eloquence to exercise the power of relating the results of natural science to man's instinct for conduct, his instinct for beauty? And here again I answer that I do not know how they will exercise it, but that they can and will exercise it I am sure. I do not mean that modern philosophical poets and modern philosophical moralists are to relate for us the results of modern scientific research to our need for conduct, our need for beauty. I mean that we shall find, as a matter of experience, if we know the best that has been thought and uttered in the world, we shall find that the art and poetry and eloquence of men who lived, perhaps, long ago, who had the most limited natural knowledge, who had the most erroneous conceptions about many important matters, we shall find that they have, in fact, not only the power of refreshing and delighting us, they have also the power—such are the strength and worth, in essentials, of their author's criticism of life—they have a fortifying and elevating and quickening and suggestive power capable of wonderfully helping us to relate the results of modern science to our need for conduct, our need for beauty. Homer's conceptions of the physical universe were, I imagine, grotesque; but really, under the shock of hearing from modern science that "the world is not subordinated to man's use, and that man is not the cynosure of things terrestrial," I could desire no better comfort than Homer's line which I quoted just now:

τλητὸν γὰρ Μοῖραι θυμὸν θέσαν ἀνθρώποισιν—

"for an enduring heart have the destinies appointed to the children of men."

And the more that men's minds are cleared, the more that the results of science are frankly accepted, the more that poetry and eloquence come to be studied as what they really are—the criticism of life by gifted men, alive and active with extraordinary power at an unusual number of points—so much the more will the value of humane letters, and of art also, which is an utterance having a like kind of

* "Iliad," xxiv, 49.

power with theirs, be felt and acknowledged, and their place in education be secured.

Let us, all of us, avoid as much as possible any invidious comparison between the merits of humane letters, as means of education, and the merits of the natural sciences. But when some President of a Section for Mechanical Science insists on making the comparison, and tells us that "he who in his training has substituted literature and history for natural science has chosen the less useful alternative," let us say to him that the student of humane letters only will at least know also the great general conceptions brought in by modern physical science; for science, as Professor Huxley says, forces them upon us all. But the student of the natural sciences only will, by our very hypothesis, know nothing of humane letters; not to mention that in setting himself to be perpetually accumulating natural knowledge, he sets himself to do what only specialists have the gift for doing genially. And so he will be unsatisfied, or at any rate incomplete, and even more incomplete, than the student of humane letters.

I once mentioned in a school-report how a young man in a training college, having to paraphrase the passage in "Macbeth" beginning,

"Canst thou not minister to a mind diseased?"

turned this line into, "Can you not wait upon the lunatic?" And I remarked what a curious state of things it would be if every pupil of our primary schools knew that, when a taper burns, the wax is converted into carbonic acid and water, and thought at the same time that a good paraphrase for

"Canst thou not minister to a mind diseased?"

was, "Can you not wait upon the lunatic?" If one is driven to choose, I think I would rather have a young person ignorant about the converted wax, but aware that "Can you not wait upon the lunatic?" is bad, than a young person whose education had left things the other way.

Or to go higher than the pupils of our primary schools. I have in my mind's eye a member of Parliament who goes to travel in America, who relates his travels, and who shows a really masterly knowledge of the geology of the country and of its mining capabilities, but who ends by gravely suggesting that the United States should borrow a prince from our royal family and should make him their king, and should create a House of Lords of great landed proprietors after the pattern of ours; and then America, he thinks, would have her future happily secured. Surely, in this case, the President of the Section for Mechanical Science would himself hardly say that our member of Parliament, by concentrating himself upon geology and mining and so on, and not attending to literature and history, had "chosen the more useful alternative."

If, then, there are to be separation and option between humane let-

ters on the one hand and the natural sciences on the other, the great majority of mankind, all who have not exceptional and overpowering aptitudes for the study of nature, would do well, I can not but think, to choose to be educated in humane letters rather than in the natural sciences. Letters will call out their being at more points, will make them live more.

And indeed, to say the truth, I can not really think that humane letters are in danger of being thrust out from their leading place in education, in spite of the array of authorities against them at this moment. So long as human nature is what it is, their attractions will remain irresistible. They will be studied more rationally, but they will not lose their place. What will happen will rather be that there will be crowded into education other matters besides, far too many; there will be, perhaps, a period of unsettlement and confusion and false tendency; but letters will not in the end lose their leading place. If they lose it for a time, they will get it back again. We shall be brought back to them by our wants and aspirations. And a poor humanist may possess his soul in patience, neither strive nor cry, admit the energy and brilliancy of the partisans of physical science, and their present favor with the public, to be far greater than his own, and still have a happy faith that the nature of things works silently on behalf of the studies which he loves, and that, while we shall all have to acquaint ourselves with the great results reached by modern science, and to give ourselves as much training in its disciplines as we can conveniently carry, yet the majority of men will always require humane letters, and so much the more as they have the more and the greater results of science to relate to the need in man for conduct, and to the need in him for beauty.

And so we have turned in favor of the humanities the "*No wisdom, nor understanding, nor counsel, against the Eternal!*" which seemed against them when we started. The "hairy quadruped furnished with a tail and pointed ears, probably arboreal in his habits," carried hidden in his nature, apparently, something destined to develop into a necessity for humane letters. The time warns me to stop; but most probably, if we went on, we might arrive at the further conclusion that our ancestor carried in his nature, also, a necessity for Greek. The attackers of the established course of study think that against Greek, at any rate, they have irresistible arguments. Literature may perhaps be needed in education, they say; but why on earth should it be Greek literature? Why not French or German? nay, "has not an Englishman models in his own literature of every kind of excellence?" As before, it is not on any weak pleadings of my own that I rely for convincing the gainsayer; it is on the constitution of human nature itself and on the instinct of self-preservation in humanity. The instinct for beauty is set in human nature, as surely as the instinct for

knowledge is set there, or the instinct for conduct. If the instinct for beauty is served by Greek literature as it is served by no other literature, we may trust to the instinct of self-preservation in humanity for keeping Greek as part of our culture. We may trust to it for even making this study more prevalent than it is now. As I said of humane letters in general, Greek will come to be studied more rationally than at present; but it will be increasingly studied as men increasingly feel the need in them for beauty, and how powerfully Greek art and Greek literature can serve this need. Women will again study Greek, as Lady Jane Grey did; perhaps in that chain of forts, with which the fair host of the Amazons is engirdling this university, they are studying it already. *Defuit una mihi symmetria prisca*, said Leonardo da Vinci; and he was an Italian. What must an Englishman feel as to his deficiencies in this respect, as the sense for beauty, whereof symmetry is an essential element, awakens and strengthens within him! what will not one day be his respect and desire for Greece and its *symmetria prisca*, when the scales drop from his eyes as he walks the London streets, and he sees such a lesson in meanness as the Strand, for instance, in its true deformity! But here I have entered Mr. Ruskin's province, and I am well content to leave not only our street architecture, but also letters and Greek, under the care of so distinguished a guardian.—*Nineteenth Century*.

WHAT ARE CLOUDS?

By C. MORFIT.

THOUGH the clouds are such familiar objects, very little is known about them, and the processes by which they are formed and give back their moisture to the earth are unsolved mysteries.

They can not be classified as belonging to the solid, fluid, or gaseous form of matter. Yet they are defined as being "a collection of watery particles in the state of *vapor*, suspended in the air." If they are ordinary vapor, they must be governed by the laws which affect vapors. Brande defines *vapor* thus: "When liquids and certain solids are heated, they become converted into elastic fluids or vapors, which differ from gases in this respect, that they are not under common circumstances permanently elastic, but resume the liquid or solid form when cooled down to ordinary temperature." According to this definition, clouds can not be composed of *ordinary* vapor, for under all conditions their temperature must be below the condensing point of water-vapor.

At the elevations at which clouds are often seen, they are in the regions of perpetual congelation; and as they float above the highest

mountains they must be exposed, even in the sunshine, and certainly in the night, when the solar heat is not poured upon them, to temperatures colder than those of the frigid zones.

As they occur in all climates, over the poles as well as at the equator, and even in the warm latitudes at elevations which are above the regions of unmelted snows, it must be assumed that a low temperature *alone* does not cause them to give up their moisture in the form of rain or snow.

Glaisher, in entering a cloud eleven hundred feet thick, found the dew-point remained unchanged, showing that there was no more (condensable) moisture in the cloud than in the surrounding air. And aëronauts obtain no dew by Regnault's hygrometer at an elevation of five miles, but clouds float above that height.

The moisture *in the air* must not be confounded with the water of the clouds. This moisture is precipitated by a low temperature, as is seen in the condensation of water on the *outside* of a glass of ice-water on a warm day, and the coating of the *inside* of window-panes with ice on a very cold one ; and the formation of dews in summer and of frosts in winter.

The precipitation of the moisture from clouds must be caused by some peculiar condition of the clouds themselves. After a rain there often are as many clouds remaining or passing away as there were at the commencement of or at any time during the rain. In this there is evidence that the action going on in a part of a single cloud, or in special clouds, does not extend over the whole mass, nor to other clouds near by.

In countries where it seldom or never rains, or where the rains are periodic, clouds are as common as in places where it rains often. From this it appears that the causes which produce precipitation are entirely suspended, or rather do not exist in certain localities and seasons, although clouds abound there at the time.

Another fact worthy of consideration is that snow and rain fall slowly, little by little, and not in one sudden down-pour, as would be the case if the whole mass of cloud or clouds were brought at the same instant under the action which produces rain or snow.

It must not be forgotten that clouds move in well-defined masses, sometimes retaining their shape for a long time, and do not disappear in the air, as they would do if they were ordinary water-vapor.

As it is difficult to reach the clouds, little has been learned of their composition. But at the elevated stations of the meteorological departments of the various nations where the observers are at times in the midst of clouds, opportunities may occur for observation and examination of them, which will reveal the laws by which they are governed. It is not too much to expect that the acute and practical minds of the present age will, ere long, add much to our present scant knowledge of these mysterious *meteors*.

THE PAST AND PRESENT OF THE CUTTLE-FISHES.*

BY DR. ANDREW WILSON.

FEW groups of the animal kingdom possess a greater interest, either for the zoölogist or for the general investigator, than that selected as the subject of the present article. From the earliest ages in which human curiosity concerning external nature began to develop into scientific observation, the cuttle-fishes have formed subject-matter of remark. In the writings of the classic naturalists they receive a due meed of attention. Their peculiarities of form and habits attracted the notice of Aristotle and Pliny; and even their development, in its more readily observed phases, was studied in the days when biology was but an infantile science. Tracing the lines of cuttle-fish lore onward through the centuries of growing culture, we discern the mediæval spirit of exaggeration and myth seizing upon the group as a likely subject for enlargement and discussion. In the fabulous history and "folk-lore" of zoölogy, the cuttle-fishes have over and over again played a more than prominent part. In the days of their mythical history they have swallowed whole fleets of ships; they have been credited more than once with the destruction of even an armored navy; and on more than one occasion there can be little doubt that they have played the parts of Sindbad's floating island, and of the "great unknown," the sea-serpent itself. To the modern zoölogist, however, eager in his search after the causes which have wrought out the existing order of animal nature, the cuttle-fishes present themselves as an unusually interesting group.

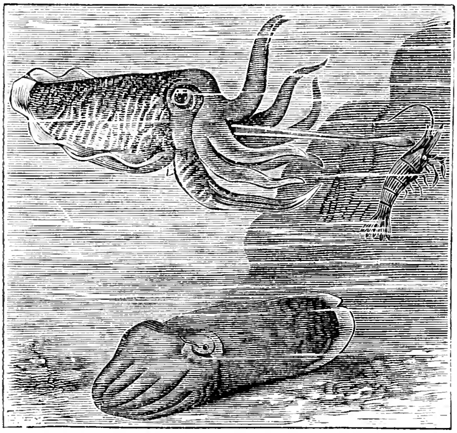

FIG. 1.—CUTTLE-FISHES SWIMMING.

* Abridged from "Belgravia."

The definition of the *Cephalopoda*, or cuttle-fish class, is largely a matter of commonplace observation. Linnæus, naming them "cephalopods," or "head-footed" mollusks, indicated the structural feature which was calculated to appeal most plainly even to non-technical minds. The circlet of arms, feet, or tentacles crowning the head-extremity of a cuttle-fish, thus presents us with a personal character of unmistakable nature. It is necessary, however, to bear in mind that the ordinary and, to a certain extent, natural fashion of representing a cuttle-fish head upward is, in zoölogical eyes, a complete reversion of its surfaces. To understand clearly why to speak of a cuttle-fish head as its *lower*, and of its tail as its *upper* extremity, is a correct zoölogical designation, we must enter upon a comparison of the cuttle-fish body with the forms of its neighbor mollusks. The contemplation of such a familiar being as a snail or whelk introduces us to a characteristic example of molluscan form and anatomy. The head of the snail or other gasteropod is clearly enough defined; and no less plainly discernible is the enlarged and broadened surface on which the animal walks. This surface is known as the "foot." In one shape or another this "foot" is a characteristic possession of the molluscan tribes. In a section of a mussel or cockle, we perceive the "foot" to exist as a muscular mass developed in the middle line of the body below, and variously used in the mussel class as a spinning organ, a leaping-pole, and a boring apparatus. Here we note the natural development of the foot in the middle line of the animal. Let us suppose this foot to be extended downward, and to be broadened so as to form a surface of progression, and we may conceive readily of the modification whereby a simple foot like that of the mussel becomes developed to form the enlarged disk of the gasteropod. In the latter case we observe that the foot occupies the floor of the body; the bulk of the body, and the head in particular, being borne above.

Cuttle-fish development can be shown to run, so far, in parallel lines to those of the personal evolution of mussel and snail. But divergent paths soon appear in cuttle-fish development; and these variations, while they indicate an ancient departure from the ordinary molluscan type, likewise give to the subjects of our present study their most characteristic features. When a mussel or snail is watched in its earlier stages of development, the embryo is seen, sooner or later, to produce an appendage highly characteristic of molluscan young at large, and named the *velum*. By aid of this ciliated fold such an organism as a young cockle, for instance, swims freely through its native waters. This velum undergoes varied changes and alterations in the after-stages of molluscan development; but, when cuttle-fish development is studied in its fullest details, no velum is found among the possessions of the larval body. Such an omission has naturally been made the subject of remark by naturalists. Some authorities—Grenacher, for instance—have insisted upon the recognition of the

arms of the cuttle-fish head as the representatives of the missing velum. But, as the latter organ always exists on the dorsal or upper side of the mouth, and as the arms are placed originally behind and under the cuttle-fish mouth, the correspondence of arms and velum has not been accepted by zoölogists. On the other side stands out the opinion of Huxley, who regards the "arms" of the cuttle-fish head as more truly corresponding with the "foot" of the mussel, snail, and other mollusks.

The margins of the foot, in this view of matters, have been prolonged in the young cuttle-fish to form eight, ten, or more arms, and the front and sides of the foot, having overgrown the mouth, are united in front, so that the mouth appears to be placed in the center of the foot, instead of in front and above it, as in other mollusks. So, also, most naturalists maintain, and with every appearance of correctness, that the characteristic "funnel" of the cuttle-fishes—to be hereafter referred to—is an organ formed by two side-processes of the foot, named *epipodia*. Adopting the view thus sanctioned by competent authority, we may trace in a cuttle-fish the highly modified form of a snail or whelk, and the still more modified form of the mussel tribes. The foot, instead of growing backward and downward as in the snail, and thus forming a broad walking disk, comes to grow over the mouth in front. So that, placing a cuttle-fish in structural comparison with a whelk or mussel, we should have to set it head downward, when the foot (or arms) would be lowest, and the great bulk of the body, with the heart uppermost, would be situated, as in the snail, above the foot.

The group of the cuttle-fishes may be said to divide itself in the most natural fashion into two main divisions. The first of these groups includes all living cuttle-fishes save one—the pearly nautilus. This first division is that of the *Dibranchiates*, or two-gilled cuttle-fishes. The familiar octopus (Fig. 1), the loligos or squids, the sepias, and the argonauts or paper nautili, are among the best known of its representatives. The second group is represented by a single living cuttle-fish, the pearly nautilus (*Nautilus Pompilius*), just mentioned, and by many fossil and extinct forms.

One of the most remarkable traits of cuttle-fish existence is the curious play of "shot" colors which takes place in their integument. I have seen a loligo, or squid, stranded on the sea-beach make glorious its dying agonies by a play of colors of the most astounding description. The natural purplish tint of the body was now and again deepened to well-nigh a dark blue; the slightest touch served to develop a patch of angry pink; and continually over the whole surface of the body the hues and tints, ranging from dark purple to light red, succeeded each other in rapid array.

The assimilation of an animal's color to the surfaces on which it rests forms a notable circumstance of zoölogy, which has been denom-

inated "mimicry." That cuttle-fishes possess such a power is well known. The hue of an octopus may so closely resemble that of the rock to which it attaches itself, that the observer can with difficulty say which is rock and which is animal. A flounder's color is in the same way assimilated to the sand on which it rests, although in the fish the alteration of color seen in the cuttle-fishes is not represented.

The manner of production of the changes of hue and play of "shot" colors in the cuttle-fishes is really analogous to that whereby the famed chameleons effect their alterations of hue.

The locomotion of the cuttle-fishes forms a point of interest in connection with their general structure and physiology. Any one who has attentively watched the movements of an octopus in its tank must have been struck by the literally acrobatic ease with which it accommodated itself to the exigencies of its life and surroundings. In their lithe, muscular, and flexible arms, the cuttle-fishes possess an apparatus which is equally serviceable for the capture of prey, and for walking mouth downward—that is, in their structurally natural position. They possess, likewise, the power of swimming upper side forward—or popularly stated "backward"—by means of the jets of water which, by forcible contractions of the muscular mantle-sac, are projected from the tube or "funnel" situated on the hinder face of the body. These *jets d'eau* consist of the effete water which has been used in breathing, so that the act of expiration and the effete water of respiration together become utilized, in the economical wisdom of nature, as a means of propulsion. The mysterious backward flight of an octopus through its tank (Fig. 1), when, detaching itself from its hold on the rock, it swims gracefully and swiftly through the water, is effected in the manner just described. This form of hydraulic apparatus, imitated in experiments in marine engineering, serves but to strengthen the wise man's adage concerning the utter lack of novelty in terrestrial and mundane things.

It is equally interesting to note that some of the squids or loligos—named popularly "flying squids"—appear to be able to rise from the surface of the sea and to spring into the air after the fashion of the flying-fishes. Instances are mentioned of the flying squids having occasionally landed themselves on the decks of ships in their atmospheric leaps.

The "arms" or "feet" demand, however, a somewhat detailed mention, on account of their armature. In all cuttle-fishes, save the exceptional pearly nautilus, the arms are either eight or ten in number, and are provided with *acetabula*, or "suckers." Those cuttles in which ten arms are present—and of these the squids and sepias form good examples—have two of these appendages produced beyond the remaining eight in length. The "suckers" (Fig. 2, A), which constitute a most noteworthy armament of the arms, are borne on short

stalks in the ten-armed cuttle-fishes, but are unstalked in the eight-armed species. Each sucker (Fig. 2) exhibits all the structures incidental to an apparatus adapted to secure effective and instantaneous adhesion to any surface. It consists of a horny or cartilaginous cup (*a*), within which are muscular fibers converging toward its center, where they form a well-defined plug or piston (*b*). By the withdrawal of this plug a partial vacuum is produced, and the suckers adhere by atmospheric pressure to the surface on which they are placed. The sucker is released by the projection of the plug and by the consequent destruction of the vacuum. The number of the suckers varies, but is always considerable; and when we reflect that the array of suckers can be instantaneously applied, and that their hold is automatically perfect, the grasp of the cephalopods is seen to be of the most efficient kind. In some cuttle-fishes, and most notably in the so-called "hooked squids" (*Onychoteuthis*), the pistons of the suckers are developed to form powerful hooks, by means of which the prey may be secured with additional facility; and in the common squids the margin of the sucker is provided with a series of minute horny hooks. The "arms" themselves, it need hardly be remarked, are extremely mobile; they are highly muscular, and can be adapted with ease to the varied functions of prehension and movement they are destined to subserve. As regards their arrangement, they are arranged in four pairs—a dorsal and a ventral pair, and two lateral pairs; the two elongated tentacles, when developed, being situated between the third and fourth pairs of arms on the ventral or lower surface.

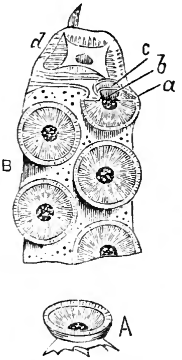

FIG. 2.—SUCKERS OF THE CUTTLE-FISH.

The alimentary tract or digestive system of the cuttle-fish race is in every respect of well-developed and complete character. Lower down in the molluscan series the commissariat department is subserved by a very perfect digestive apparatus, including representatives of most of the organs familiar enough to us in higher or vertebrate existence. In the cephalopods we should naturally expect the standard of lower molluscan organization to be further elaborated; and this anatomical expectation is justified by the actual details of cuttle-fish structure. The mouth opens on the upper surface of the head—a disposition of matters already accounted for when considering the relations of the cuttle-fish body to that of other mollusks. The mouth-opening is usually bounded by a raised lip, and leads into a cavity containing an elaborate apparatus, analogous to the jaws of higher animals, and by means of which the food of these animals is triturated and divided. An inspection of the masticating apparatus of a cuttle-fish readily solves the question, "How are the hard shells of their

crustacean food broken down?" There exists within the mouth, firstly, a hard, horny beak, resembling closely in shape the beak of a parrot, and consisting of two chief divisions, whereof one—the front—is the smaller, and is overlapped by the hinder beak. Set in action by appropriate muscles, these beaks divide the hard parts of the food with the greatest ease. But a second apparatus of more typical nature likewise exists in these animals. This is the *odontophore*, a structure popularly named the "tongue," and which is common to the whelk and snail class, to the sea-butterflies, and to the cuttle-fishes. It consists essentially of an elongated ribbon-like structure, bearing hooked teeth, generally disposed in transverse rows. This apparatus, set in action by special muscles, and worked after the fashion of a chain-saw, is used to rasp down the food; while new growths of its substance from behind serve to repair the loss caused by the friction to which it is subjected.

The gills, as already noted, number two in all cuttle-fishes except the pearly nautilus, and may demand a special notice. Each gill is a conical organ, consisting essentially of a dense net-work of blood-vessels, in which impure blood brought by the great veins is exposed to the action of the oxygen contained in the water which is being continually admitted to the gill-chambers. Each gill is contained within a kind of chamber to which water is admitted by the front edge of the mantle-sac. This opening being closed by a valve against the exit of the water, the forcible contraction of the body-walls ejects the water, as previously described, from the "funnel." The gills are themselves contractile, but they do not possess the armament of minute vibratile processes or *cilia*, so typical of the gills of other mollusca. The need for these cilia as organs providing for the circulation of water over the gill-surfaces is of course removed, in view of the very perfect means existent in the cuttle-fishes for the renewal of the water used in breathing. As a living octopus or other cuttle-fish is watched, the movements of inspiration and expiration are plainly indicated by the expansion and contraction of the body-walls, and they imitate in a singularly exact fashion the analogous movements of the highest animals. Observers have likewise described in certain members of the cuttle-fish class a series of minute pores, by which water enters the great veins and mixes with the blood. It is also certain that water enters the general body cavity and bathes the organs of the animal, thus converting that cavity into a physiologically active space, possessing an influence on the circulation in that its contained water presents a medium for the conveyance of oxygen into, and for the reception of waste materials from, the blood.

Connected on the one hand with the digestive system, and on the other with the more purely glandular structures of the body, is the organ known familiarly as the "ink-bag" of these animals. The cuttle-fishes are well known to utilize the secretion of this sac as a means of

defense, and for enabling them to escape from their enemies. Discharging the inky fluid through the "funnel," into which the duct of the ink-sac opens, it rapidly diffuses itself through the water, and enables the animal to escape under a literal cloak of darkness. The exact nature and relationship of this ink-sac to the other organs of the cuttle-fish have long been disputed. According to one authority, the ink-bag represented the gall-bladder, because in the octopus it is imbedded in the liver. From another point of view, it was declared to represent an intestinal gland; while a third opinion maintained its entirely special nature. The ink-sac is now known to be developed as an offshoot from the digestive tube; and, taking development as the one infallible criterion and test of the nature of living structures, we may conclude that it represents at once a highly specialized part of the digestive tract, and an organ which, unrepresented entirely in the oldest cuttle-fishes, has been developed in obedience to the demands and exigencies of the later growths of the race. It is this ink-sac which is frequently found fossilized in certain extinct cuttle-fish shells. Its secretion forms the original *sepia* color, a term derived from the name of a cuttle-fish genus. The fossilized sepia has been used with good effect when ground down. The late Dean Buckland gave some of this fossil ink to Sir Francis Chantrey, who made with it a drawing of the specimen from which it had been taken; and Cuvier is said to have used this fossilized ink in the preparation of the plates wherewith he illustrated his "Mollusca." At the present time, recent cuttle-fish ink is said to be utilized in the manufacture of ordinary artists' "sepia."

The due regulation of cuttle-fish existence is determined by the action of its nervous apparatus. The ordinary type of molluscan nervous system undergoes in the cuttle-fishes a decided change of form. In a snail or whelk, for example, the nervous system exhibits an arrangement of three chief nerve-masses or "ganglia," connected by nervous cords. Of these three nerve-centers, one is situated in the head, a second in the "foot" or organ of movement, and a third in the neighborhood of heart and gills, or amid the viscera generally. Increased concentration of this type of nerve-arrangement awaits us in cuttle-fish organization. Just as the spider possesses a more concentrated and localized nerve-axis than the insect, or as the gangliated chain of the latter becomes the fused nerve-mass of the spider, so in the cuttle-fish, the molluscan nerve-system, scattered and diffused in the snail, whelk, or mussel, becomes localized in adaptation to the increased nerve-control and to the wider instincts of cuttle-fish existence. This process of nerve-localization and concentration is accompanied by certain important modifications affecting other regions and structures of cuttle-fish economy. Thus the nerve-centers are found to be protected and inclosed within a gristly or cartilaginous case, that foreshadows the functions of the vertebrate skull, though in no sense connected with that structure.

Not the least interesting feature of this localized mass of nervous matter is the fact that it exhibits the same arrangement of gray and white nerve-matter that is seen in the highest brains. An outer gray and an inner white layer are discernible in the nerve-ganglia of cephalopods, as in the cerebrum of man; and, as in the highest animals, the cuttle-fish gray matter is found to consist of nerve-cells, while the white matter is chiefly composed of nerve-fibers. Thus the laws of developmental progress affect the microscopic and intimate structure of the living form as well as the more obvious details of structure. From the main nerve-mass of the cuttle-fishes nerves arise to supply the body at large. Nerves of special sense supply eyes, ears, and olfactory organs; while the viscera and the "mantle" or general body-covering are also well provided with the means of innervation.

Cuttle-fish existence possesses, in all probability, the five "gateways of knowledge," through which the impressions of the outer world are received, and by which these impressions are modified and transmitted to the brain-masses as sensations of sight, hearing, smell, touch, and taste. There is little need to draw upon hypothesis in the assumption that the arms or tentacles are efficient organs of touch in Cephalopoda, or that the structures of the mouth may subserve taste, in so far as the latter sense may be required to satisfy the demands of cuttle-fish existence. An organ of smell is definitely situated behind or above the eyes. There two small projections, or, as frequently, two minute pits or depressions, occur. These pits are ciliated, and between the cilia "olfactory cells" are situated. These cells, in turn, represent the similar structures which occur in higher animals, and which, in man himself, form the characteristic terminations to his olfactory nerves. That the cuttle-fishes can literally scent their prey from afar off is an idea confirmed by the facts of their every-day life.

The "ears" of the cuttle-fishes present us with two sacs—named "auditory sacs"—which may, as in the nautilus, either be attached to the chief nerve-mass itself, or, as in the two-gilled cuttles, be lodged in special cavities in the gristly "skull." A cuttle-fish "ear" is essentially a sac or bag, called an "otocyst," containing either one or many "otoliths" or "ear-stones," suspended in a watery fluid. This, indeed, is the primitive type of "ear" we may find even in the *Medusidæ* or "jelly-fishes" themselves. The ear-sacs of many cuttle-fishes open on the external surface of the body by two fine canals, named "Kölliker's ducts," after their distinguished discoverer. Occasionally these ducts end blindly, and do not open on the body surface. These facts lend additional support to the opinion that in the ear of the cuttle-fish we find primitive structures proper to the ears of vertebrates, the minute canals of Kölliker corresponding with the *recessus vestibuli* of the vertebrate organ of hearing. Once again, therefore, we find the progressive development of cephalopods and vertebrates

running in parallel, but nevertheless in distinct and independent, lines; and this likeness is further strengthened when we discover that not merely the ear, but the eye likewise, of these two groups of animals is formed or developed in an essentially similar fashion. The ear of the cuttle-fish presents us with a permanent example of an early and transitory stage in the development of the vertebrate ear, and a common plan of ear-production is thus seen to traverse a wide extent of the animal world.

The present history of the cuttle-fishes may be concluded by the briefest possible reference to their distribution and classification. Over two thousand species of cephalopods are known. But geology claims the vast majority, only two hundred and eighteen species being included in the ranks of living animals. The cuttle-fishes are very widely distributed in existing seas. They occur in the far north; they are plentifully represented in the colder seas by the squids which form the bait of the Newfoundland cod-fishers; but in tropical regions they attain their greatest size and numerical strength. Their classification is both simple and natural. Their division into *Dibranchiates* ("two-gilled") and *Tetrabranchiates* ("four-gilled") is a method of arrangement which accurately reflects variations in their existing structure, as it correctly indicates the main lines of their geological and past history. Of four-gilled cuttle-fishes there is but one living example—the pearly nautilus (Fig. 3). Its special and distinctive peculiarities may be rapidly summed up in the statement that it has

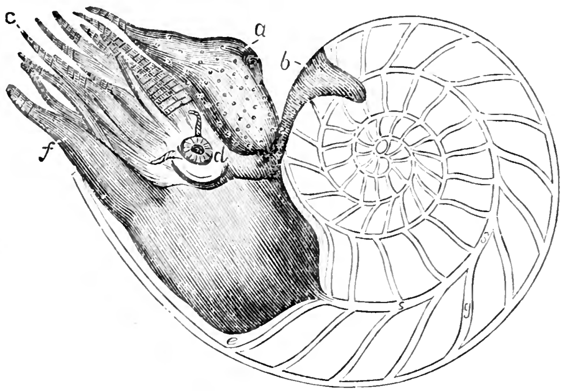

FIG. 3.—PEARLY NAUTILUS.

four gills, numerous arms (*c*), no suckers, no ink-sac, an incompletely tubular funnel (*f*), stalked eyes, and an external, many-chambered shell, in the last formed and largest compartment (*e*) of which the body is lodged.

The absence of an ink-sac in the nautilus is a fact correlated with its bottom-living habits and with the absence of any need or require-

ment for the sudden concealment from enemies which the more active two-gilled forms demand. The many-chambered shell of the pearly nautilus exhibits a flat, symmetrical, spiral shape. Its many-chambered state is explained by the fact that as the animal grows it successively leaves the already formed chambers, and secretes a new chamber to accommodate the increasing size of body. Each new chamber is partitioned off from that last occupied by a shelly wall called a *septum* (*g*). Through the middle of the series of septa runs a tube named the *siphuncle* (*s*, *s*), whose function has been credited with being that of maintaining a low vitality in the disused chambers of the shell.

All other living cuttle-fishes possess, on the contrary, two gills, never more than ten arms provided with suckers, an ink-sac, unstalked eyes, a completely tubular funnel, and an internal shell. If, however, the nautilus represents in its solitary self the four-gilled cuttle-fishes of to-day, it likewise, like "the last of the Mohicans," appears as the descendant of a long line of famous ancestors. In its distribution, the nautilus is limited to the southern seas. It is still the rarest of animals in our museums, although its shells are common enough.

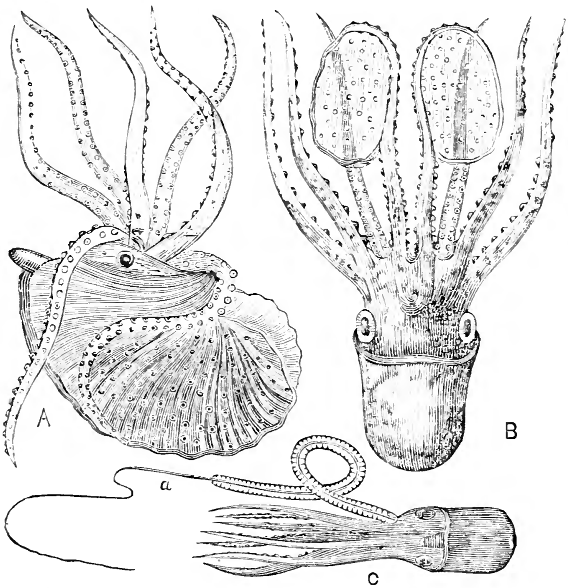

FIG. 4.—PAPER NAUTILUS. A, female argonaut showing shell, around which the two expanded arms are clasped; B, female removed from shell; C, the male argonaut (shell-less).

This, according to Mr. Moseley, is no doubt due to the fact that the animal is mostly an inhabitant of deep water. The shells of *Spirula* (Fig. 6) similarly occur in countless numbers on tropical beaches, yet the animal has only been procured two or three times.

It is thus the pearly nautilus floats under certain circumstances on the surface of the water. The argonaut (Fig. 4), credited in poetry and fiction with this power, never floats on the surface, as was of old believed. It is simply a mundane cuttle-fish, whose two expanded arms are never used as sails, after the popularly supposed fashion, but are employed solely to secrete and attach to the body the false shell (Fig. 4, A) with which it is provided.

Among the two hundred odd living two-gilled cuttle-fishes, considerable diversity of external form may be seen; but the general type

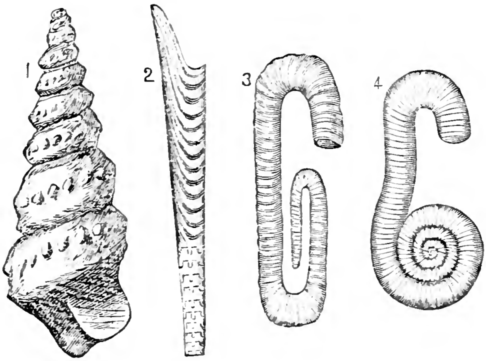

Fig. 5.—Shells of Fossil Cuttle-fishes. 1, Turrilites; 2, Baculites; 3, Hamites; 4, Scaphites.

already described is at the same time closely adhered to; and save in the case of the paper nautilus or argonaut, in which the characteristic shape of body is concealed by the shell, the cuttle-fish characters are readily apparent. The shell of the paper nautilus (Fig. 4, A) is termed "false" or "pedal," because it is not formed by the mantle, as all true shells are, but by the two expanded arms, as already mentioned. In its homology it therefore coincides with foot-secretions (such as the "beard" of the mussel), and not with the shells of its neighbors. The female argonaut alone possesses a "shell," the male (Fig. 4, C) being a diminutive creature, measuring only an inch or so in length. It is in the ranks of the two-gilled cuttle-fishes that we discover those phases of cuttle-fish life which most characteristically appeal to the popular mind. Thus, many species of two-gilled cuttles are eaten and considered dainties by foreign nations; it is from this group that the sepia color already mentioned is obtained; their internal shells gave us the "pounce" of long ago, and formed an article in the materia medica of by-gone days; and, lastly, it is in this group that the mythical and the real meet in the consideration of the giant cuttle-fishes which the myth and fiction of the past postulated, and which modern zoölogy numbers among its realities.

The past history of the cuttle-fishes unites in itself a knowledge at once of their present position in the animal world and of their prog-

ress toward that position. The history of their past begins with the recognition of the pearly nautilus (Fig. 3) as a being which, as a four-gilled cuttle-fish possessing an external many-chambered shell, stands alone in the world of life. It is the tribes of two-gilled cuttle-fishes which people our ocean to-day, and which exhibit all the gradations of form and size, from the minute *Spirula* (Fig. 6) to the great *Architeuthis* of the American coasts. The history of the cuttle-fishes in time begins in the far-back epoch represented by the Lower Silurian rocks of the geologist. There are entombed the first fossil cuttle-fishes, represented by their chambered shells. The genus *Orthoceras*, represented by shells of straight form, is thus among the oldest members of the cuttle-fish race. The *Nautilus* genus itself begins in the Upper Silurian rocks; we may trace the well-known shells upward to the Carboniferous strata, where they are best developed; and we follow the genus onward in time, as it decreases in numbers, until we arrive at the existing order of things, in which the solitary nautilus remains, as we have seen, to represent in itself the fullness of cephalopod life in the oceans of the past. The older or Palæozoic rocks reveal a literal wealth of these chambered shells, and therefore of the existence of the four-gilled cuttle-fishes as the founders of the race. When we ascend to the Mesozoic rocks (ranging from the Trias to the Chalk), we meet with new types of the chambered shells well-nigh unknown in the Palæozoic period. In the Mesozoic rocks appears the fullness of *Ammonite* life. Here we find shells named after the horns of the Egyptian god, Jupiter Ammon; these, instead of being tolerably plain, like the *Nautilidæ*, exhibit beautifully sculptured outlines, and folded septa, or partitions, between the chambers of the shell. The shells allied to *Nautilus* and occurring in the Palæozoic formations differ from Nautilus chiefly in their varying degrees of curvature or straightness. *Lituites* is a curved form allied to *Nautilus;* while *Orthoceras* and *Gomphoceras* are groups representing the straightened forms. But in the Silurian period more complex forms appear, with elaborate and folded septa. These are the early Ammonites, such as *Goniatites* and *Bactrites*. In the Secondary rocks we find the still more complex true Ammonites themselves. Here the *lobes* and *saddles* of the shells, as the edges of the septa are named, are of the most elaborate patterns, while the shapes of shell are of the most varied character (*Baculites, Turrilites, Ammonites*, etc., Fig. 5).

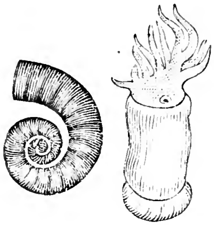

Fig. 6.—Spirula.

There is thus an advance and progression exhibited in the development of the four-gilled races which accords perfectly with the theory of evolution and descent. The seas of the Trias, Oolite, and Chalk periods must have literally swarmed with these striking forms of cephalopod life; but as the close of the Chalk period dawned, and as

the Secondary age came to an end, the fullness of the Ammonite generations disappeared for ever. In the succeeding Tertiary period not a single Ammonite of any kind occurs; the genus *Nautilus* remaining in the Tertiary period—as it survived into the Mesozoic or middle period—as the sole representative of a once plentiful four-gilled population.

If the history of the four-gilled cuttle-fishes is thus plainly told as having its beginnings in the Palæozoic period, its maximum development in the Mesozoic period, and its lingering presence in the Tertiary period, the two-gilled cuttle-fishes may be said to possess an equally interesting history. Compared with their four-gilled neighbors, the two-gilled forms are late comers upon creation's scene. Not a single fossil two-gilled form occurs in all the Palæozoic period, extending from the Laurentian to the Permian rocks. If they existed in Palæozoic seas, they have at least left no trace of their presence. Their softness of body may perchance have contributed to their elimination from the oldest fossil records; but, laying aside mere conjecture, we find the first fact of the past history of the two-gilled forms in the presence of the fossil shells of the extinct *Belemnites* in the Triassic rocks. The Belemnites themselves disappear at the close of the Mesozoic period; but fossilized shells of species allied to our living Sepias occur in the Oolite; and the internal shells of squids are found in the Lias or lower Oolites. In the Tertiary rocks, Argonaut (Fig. 4) shells occur in the Pliocene deposits; the Eocene rocks also give us sepia remains; and various other two-gilled fossils (*Beloptera*, etc.) are found in Eocene and Miocene formations.

Briefly summarized, then, we find that the chief details in the past history of the cuttle-fishes are told when we are reminded that the four-gilled forms are by far the more ancient of the two groups; that they first appear in the Silurian rocks, while the two-gilled forms appear first in the Secondary rocks; and, lastly, that the record of the one group is the converse of the other. For, the four-gilled species attained their maximum in the Primary and Secondary rocks, and have practically died out, leaving the pearly nautilus as their sole representative in existing seas. The two-gilled race, starting in the Secondary rocks, and leaving the extinct belemnites as a legacy to the past, have, on the other hand, flourished and progressed, and attain their maximum, both in size and numbers, in the existing seas and oceans of our globe.

What ideas concerning the origin and evolution of these animals may be legitimately deduced from the foregoing facts of their structure and distribution in time? In the answer to such a question, asked concerning any group of living beings, lies the culminating point of all biological science. That the cuttle-fishes fall nominally into their place in the scale of being indicated by evolution, and that in their individual development, in the growth of their special organs, such as

eye and ear, as well as in the general relations they bear to each other as living forms, they illustrate the results of progressive development, can not for a moment be doubted. The further fact that the existing four-gilled nautilus, despite its lengthy ancestry, as regards its brain, its eye, its tentacles, and other features of its history, is a less specialized and lower form than the two-gilled cuttle-fishes, clearly points to the evolution of the two-gilled from the four-gilled stock. The more active and structurally higher races of to-day, in other words, have sprung from the less specialized and lower cuttle-fishes of the geological yesterday. No question, then, of the reality of progressive development, as a factor in evolving new species and groups of cuttle-fishes from the confines of already formed species, can be entertained.

Turning more specifically to the shell in general, we may discover in the modifications of this single structure a clew to the entire evolution of the cuttle-fish race. The "shells" of the two-gilled cuttle-fishes exist for the most part as horny "pens" or as limy plates, secreted by the "shell-gland" of the mantle which forms the true shell of all mollusks. Starting with the shells which are certainly oldest in point of time, and therefore of development, we find, in the Nautili and their neighbors, structures which represent fullness of shell-growth. It appears a long hypothetical journey from the well-developed shell of the nautilus type to the limy plate or horny "pen" shell of the squid. But the halting-places on the way diminish the apparent length of the journey, as they lessen the seeming irregularity of the path. The simple rudimentary shells of our two-gilled cuttle-fishes are to be regarded as the degenerate remains of structures fully developed in their ancestors. To this idea, their succession in time bears faithful witness; and to its correctness the connecting links, accessible to us, plainly testify.

Thus the history of the cuttle-fish shell forms an important chapter in the biography of the race. The rudimental shells of the two-gilled cuttle-fishes, like the teeth which never cut the gum in unborn whales, have a reference not to their present life, but to a former state of things. Contemplating the "pen" or "cuttle-bone" of a modern squid or sepia, our thoughts become molded in mental continuity with the past. There rise to view before our mind's eye the ancient Nautili and their sculptured kith and kin the ammonites, crowding the sea-beds of the far-back Mesozoic, and still more remote Palæozoic ages. Then, through the operation of the inevitable laws of organic progress and advance—making the ancient world then, as they constitute our world to-day, the theatre of continual change—we see the two-gilled stock arise in secondary times from the four-gilled race. First there is seen the modification of shell. Concurrently with the decrease of shell comes increase of head-development and elaboration of nerve-centers, tending to make the new two-gilled form what we know it to be to-day—the wary, watchful organism, living in the waters above,

and occupying a sphere of vital activity immeasurably superior to the dull existence passed by its four-gilled ancestors on the ocean-bed. The shell degenerates more and more as the cuttle-fish race rises on its own branch of the animal tree. Development in numbers succeeds individual advance. The cephalopod tribes of to-day dawn fuller and fuller as the Tertiary period progresses. Thus the fullness of cuttle-fish life to-day, exhibited in all its strange weirdness, is interwoven, like the lines of human history itself, with the warp and woof of the past. And not the least important clew to the history of that past is found in the apparently insignificant "shell" we have discussed; since in its mere degeneracy it leads us backward in an instructive glance to those early times when the chief branches on life's tree had not reached their full fruition, and to the days when the world itself was young.

MOZLEY ON EVOLUTION.

By HERBERT SPENCER.

IN the "Reminiscences, chiefly of Oriel College," by the Rev. Thomas Mozley, there occurs on page 146, vol. i, the following passage:

> I had indulged from my boyhood in a Darwinian dream of moral philosophy, derived in the first instance from one of my early instructors. This was Mr. George Spencer, [honorary] Secretary of the Derby Philosophical Association, founded by Dr. Darwin,* and father of Mr. Herbert Spencer. My dream had a certain family resemblance to the "System of Philosophy" bearing that writer's name. There was an important and saving difference between the two systems, between that which never saw the light, and perished before it was born, without even coming to wither like grass on the house-tops, and that other imposing system which occupies several yards of shelf in most public libraries. The latter makes the world of life, as we see, and take part in it, the present outcome of a continual outcoming from atoms, lichens, and vegetables, bound by the necessities of existence to mutual relations, up to or down to brutes, savages, ladies and gentlemen, inheriting various opinions, maxims, and superstitions. The brother and elder philosophy, for such it was, that is mine, saved itself from birth by its palpable inconsistency, for it retained a divine original and some other incongruous elements. In particular, instead of rating the patriarchal stage hardly above the brute, it assigned to that state of society a heavenly source, and described it as rather a model for English country gentlemen—that is, upon the whole, and with certain reservations.

As I find, by inquiring of those who have read it, this passage leaves the impression that the doctrines set forth in the "System of

* It was more than a dozen years after Dr. Darwin's death in 1802 when my father became honorary secretary. I believe my father (who was twelve years old when Dr. Darwin died) never saw him, and, so far as I know, knew nothing of his ideas.

Synthetic Philosophy," as well as those which Mr. Mozley entertained in his early days, were in some way derived from my father. Were this true, the implication would be that during the last five-and-twenty years I have been allowing myself to be credited with ideas which are not my own. And, since this is entirely untrue, I can not be expected to let it pass unnoticed. If I do, I tacitly countenance an error, and tacitly admit an act by no means creditable to me.

I should be the last to underestimate my indebtedness to my father, for whom I have great admiration, as will be seen when, hereafter, there comes to be published a sketch of him which I long ago prepared in rough draft. But this indebtedness was general and not special—an indebtedness for habits of thought encouraged rather than for ideas communicated. I distinctly trace to him an ingrained tendency to inquire for causes—causes, I mean, of the physical class. Though far from having himself abandoned supernaturalism, yet the bias toward naturalism was strong in him, and was, I doubt not, communicated (though rather by example than by precept) to others he taught as it was to me. But while admitting, and indeed asserting, that the tendency toward naturalistic interpretation of things was fostered in me by him, as probably also in Mr. Mozley, yet I am not aware that any of those *results* of naturalistic interpretation distinctive of my works are traceable to him.

Were the general reader in the habit of criticising each statement he meets, he might be expected to discover in the paragraph quoted above from Mr. Mozley reasons for skepticism. When, for example, he found my books described as occupying several yards of library-shelves, while in fact they occupy less than two feet, he might be led to suspect that other statements, made with like regard for effectiveness rather than accuracy, are misleading. A reperusal of the last part of the paragraph might confirm his suspicion. Observing that, along with the allegation of "family resemblance," the closing sentence admits that the course of human affairs as conceived by Mr. Mozley was the reverse in direction to the course alleged by me—observing that in this only respect in which Mr. Mozley specifies his view it is so fundamentally anti-evolutionary as to be irreconcilable with the evolutionary view—he might have further doubts raised. But the general reader, not pausing to consider, mostly accepts without hesitation what a writer tells him.

Even scientific readers, even readers familiar with the contents of my books, can not, I fear, be trusted so to test Mr. Mozley's statement as to recognize its necessary erroneousness; though a little thought would show them this. They would have but to recall the cardinal ideas developed throughout the series of volumes I have published, to become conscious that these ideas are necessarily of much later origin than the period to which Mr. Mozley's account refers. Though, in Rumford's day and before, an advance had been made toward the doc-

trine of the correlation of heat and motion, this doctrine had not become current; and no conception, even, had arisen of the more general doctrine of the correlation and equivalence of the physical forces at large. Still more recent was the rise and establishment of the associated abstract doctrine commonly known as the "conservation of energy." Further, Von Baer's discovery, that the changes undergone during development of each organic body are always from the general to the special, was not enunciated till some eight years after the time at which Mr. Mozley was a pupil of my father, and was not heard of in England until twenty years after. Now, since these three doctrines are indispensable elements of the general theory of evolution (the last of them being that which set up in me the course of thought leading to it), it is manifest that not even a rude conception of such a theory could have been framed at the date referred to in Mr. Mozley's account. Even apart from this, one who compared my successive writings would find clear proof that their cardinal ideas could have had no such origin as Mr. Mozley's account seems to imply. In the earliest of them—"Letters on the Proper Sphere of Government"—published in 1842 and republished as a pamphlet in 1844, the only point of community with the general doctrine of evolution is a belief in the modifiability of human nature through adaptation to conditions (which I held as a corollary from the theory of Lamarck) and a consequent belief in human progression. In the second and more important one, "Social Statics," published in 1850, the same general ideas are to be seen, worked out more elaborately in their ethical and political consequences. Only in an essay published in 1852 would the inquirer note for the first time a passing reference to the increase of heterogeneity as a trait of development, and a first recognition of this trait as seen in other orders of phenomena than those displayed by individual organisms. Onward through essays published in several following years, he would observe further extensions in the alleged range of this law; until, in 1855, in the "Principles of Psychology," it begins to take an important position, joined with the additional law of integration, afterward to be similarly extended. Not until 1857, in two essays then published, would he find a statement, relatively crude in form, of the law of evolution, set forth as holding throughout all orders of phenomena, and joined with it the statement of certain universal physical principles which necessitate its universality. And only in 1861 would he come to an expression of the law approximating in definiteness to that final one reached in 1867. All which facts the scientific reader who took the trouble to investigate would see are conclusive against the implication contained in Mr. Mozley's statement; since, were this implication true, my early writings would have contained traces of the specific doctrine set forth in the later ones. But, as I have said, even a reader of my books can not be trusted to recall and consider these facts, but will certainly, in many

cases, and probably in most, passively accept the belief Mr. Mozley suggests.

Seeing this, I have felt it requisite definitely to raise the issue; and for this purpose have written to Mr. Mozley the following letter. It is made long by including a general outline of the doctrine of evolution, which it was needful to place before him that he might be in a position to answer my question definitely. Perhaps I may be excused for reproducing the letter in full, since ninety-nine out of a hundred do not know what the doctrine of evolution in its wider sense is, but suppose it to be simply another name for the doctrine of the origin of species by natural selection:

"My dear Sir: The passages from three letters of my father, sent herewith—one written in 1820, which was about the date referred to in your account of him, one written some thirteen years later, and the other twenty years later—will prove to you how erroneous is the statement you have made with regard to his religious beliefs. Having in this case clear proof of error, you will, I think, be the better prepared to recognize the probability of error in the statements which you make concerning his philosophical ideas and the ideas which, under his influence, you in early life elaborated for yourself.

"The passage in which you refer to these gives the impression that they were akin to those views which are developed in the 'System of Synthetic Philosophy.' I am anxious to ascertain in what the alleged kinship consists. Some twelve years ago an American friend requested me, with a view to a certain use which he named, to furnish him with a succinct statement of the cardinal principles developed in the successive works I have published. The rough draft of this statement I have preserved; and, that you may be enabled definitely to compare the propositions of that which you have called 'the younger philosophy' with that which you have called 'the elder,' I copy it out. It runs as follows:

"'1. Throughout the universe in general and in detail there is an unceasing redistribution of matter and motion.

"'2. This redistribution constitutes evolution where there is a predominant integration of matter and dissipation of motion, and constitutes dissolution where there is a predominant absorption of motion and disintegration of matter.

"'3. Evolution is simple when the process of integration, or the formation of a coherent aggregate, proceeds uncomplicated by other processes.

"'4. Evolution is compound when, along with this primary change from an incoherent to a coherent state, there go on secondary changes due to differences in the circumstances of the different parts of the aggregate.

"'5. These secondary changes constitute a transformation of the homogeneous into the heterogeneous—a transformation which, like the first, is exhibited in the universe as a whole and in all (or nearly all) its details; in the aggregate of stars and nebulæ; in the planetary system; in the earth as an inorganic mass; in each organism, vegetal or animal (Von Baer's law otherwise ex-

pressed); in the aggregate of organisms throughout geologic time; in the mind; in society; in all products of social activity.

"'6. The process of integration, acting locally as well as generally, combines with the process of differentiation to render this change not simply from homogeneity to heterogeneity, but from an indefinite homogeneity to a definite heterogeneity; and this trait of increasing definiteness, which accompanies the trait of increasing heterogeneity, is, like it, exhibited in the totality of things and in all its divisions and subdivisions down to the minutest.

"'7. Along with this redistribution of the matter composing any evolving aggregate there goes on a redistribution of the retained motion of its components in relation to one another; this also becomes, step by step, more definitely heterogeneous.

"'8. In the absence of a homogeneity that is infinite and absolute, that redistribution, of which evolution is one phase, is inevitable. The causes which necessitate it are these:

"'9. The instability of the homogeneous, which is consequent upon the different exposures of the different parts of any limited aggregate to incident forces. The transformations hence resulting are complicated by—

"'10. The multiplication of effects. Every mass and part of a mass on which a force falls subdivides and differentiates that force, which thereupon proceeds to work a variety of changes; and each of these becomes the parent of similarly-multiplying changes; the multiplication of them becoming greater in proportion as the aggregate becomes more heterogeneous. And these two causes of increasing differentiations are furthered by—

"'11. Segregation, which is a process tending ever to separate unlike units and to bring together like units—so serving continually to sharpen, or make definite, differentiations otherwise caused.

"'12. Equilibration is the final result of these transformations which an evolving aggregate undergoes. The changes go on until there is reached an equilibrium between the forces which all parts of the aggregate are exposed to, and the forces these parts oppose to them. Equilibration may pass through a transition stage of balanced motions (as in a planetary system), or of balanced functions (as in a living body), on the way to ultimate equilibrium; but the state of rest in inorganic bodies, or death in organic bodies, is the necessary limit of the changes constituting evolution.

"'13. Dissolution is the counter-change which sooner or later every evolved aggregate undergoes. Remaining exposed to surrounding forces that are unequilibrated, each aggregate is ever liable to be dissipated by the increase, gradual or sudden, of its contained motion; and its dissipation, quickly undergone by bodies lately animate and slowly undergone by inanimate masses, remains to be undergone at an indefinitely remote period by each planetary and stellar mass, which since an indefinitely distant period in the past has been slowly evolving; the cycle of its transformations being thus completed.

"'14. This rhythm of evolution and dissolution, completing itself during short periods in small aggregates, and in the vast aggregates distributed through space completing itself in periods which are immeasurable by human thought, is, so far as we can see, universal and eternal—each alternating phase of the process predominating now in this region of space and now in that, as local conditions determine.

"'15. All these phenomena, from their great features down to their minutest details, are necessary results of the persistence of force, under its forms of mat-

ter and motion. Given these as distributed through space, and their quantities being unchangeable, either by increase or decrease, there inevitably result the continuous redistributions distinguishable as evolution and dissolution, as well as all those special traits above enumerated.

"'16. That which persists unchanging in quantity but ever changing in form, under these sensible appearances which the universe presents to us, transcends human knowledge and conception—is an unknown and unknowable power, which we are obliged to recognize as without limit in space and without beginning or end in time.'

"I am not aware that my father entertained any of these views, either definitely or vaguely. But if he did, or if under his influence you reached views similar to these or any of them, it will, I presume, be possible to indicate the resemblances. Or, if specific resemblances are not alleged, still it will be possible to point out what were the ideas you received from him which potentially involved conclusions such as are above set forth.

"I fear I am entailing some trouble upon you in asking an answer to this question, but the importance of the matter must be my apology.

"I am, my dear sir, faithfully yours,

"HERBERT SPENCER."

In Mr. Mozley's reply he stated that he had been obliged already to send off his corrections for a second edition, adding that, "as, therefore, nothing can be done now, you would not care for any discussion." The result is, that I remain without any reply to my question. One passage, however, in Mr. Mozley's letter serves to give a widely different meaning to his statement; and, having obtained his permission, I here quote it as follows: "You will observe that I have only a vague idea of my own 'philosophy,' and I can not pretend to an accurate knowledge of yours. I spoke of a 'family likeness.' But what is that? There is a family likeness between Cardinal Newman's view and his brother Frank's."

Now, if the "family likeness" alleged is not greater than that between the belief of a Roman Catholic and the belief of a Rationalist who retains his theism, my chief objection is removed; for just as the views of the brothers Newman have a certain kinship in virtue of the religious sentiment common to them, so Mr. Mozley's early views and my own may have had the common trait of naturalistic interpretation—partially carried out in the one and completely in the other: a common trait, however, which would give Mr. Mozley's early views a "family likeness" to other philosophies than mine. This being understood, the only further objection to Mr. Mozley's statement which I have to make is that I do not see how, even in this vague sense, a likeness can be alleged between that which he names and describes as "a *moral* philosophy" and "a system of philosophy" of which the greater part is concerned with the phenomena of evolution at large—inorganic, organic, and super-organic—as interpreted on physical prin-

ciples, and of which only the closing portion sets forth ethical conclusions as corollaries from all the conclusions that have preceded.

There remains only to answer the question, How could Mr. Mozley have been led to imagine a resemblance between things so different? He has himself gone far toward furnishing an explanation. In his introduction (page 1) he admits, or rather asserts, that "reminiscences are very suspicious matter"; and that "the mental picture of events long passed by, and seen through an increasing breadth of many-tinted haze, is liable to be warped and colored by more recent remembrances, and by impressions received from other quarters." He adds sundry illustrations of the extreme untrustworthiness of memory concerning the remote past; and in chapter lxxxiii he characterizes Denison's "Reminiscences of Oriole College" as a "jumble of inaccuracies, absurdities, and apparent forgets." Moreover, he indicates (page 4) a special cause of distortion, saying of those "whose memory is subordinate to imagination and passion" that "they remember too easily, too quickly, and too much as they please." Now, as is implied by his religious ideas and ecclesiastical leanings, and as is also shown by a passage in which he refers to the scientific school with manifest aversion, Mr. Mozley is biased toward an interpretation which tends to discredit this school, or a part of it; and, obviously, to fancy a resemblance between scientific views now current and those which he describes as a "dream" of his youth, which disappeared with his manhood, is not unsatisfactory. On looking through the "many-tinted haze" of sixty years at what he admits to be "a vague idea" of his early philosophy, he has unconsciously "warped and colored" it, and imagined in it a resemblance which, as I have shown, it could not possibly have had.

I will add only that serious injustice is apt to be done by publication of reminiscences which concern others than the writer of them. Widely diffused as is Mr. Mozley's interesting work, his statement will be read and accepted by thousands who will never see this rectification.—*Athenæum.*

EXPLOSIONS AND EXPLOSIVES.

By ALLAN D. BROWN,
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THE chief explosive mixture used in the arts of war and peace will probably for a long time continue to be that which we know by the name of gunpowder. It has been used so long that its origin (like that of the mariner's compass) is entirely lost in the misty atmosphere of the middle ages, if indeed it was not known before the Christian era. The ingredients spoken of by Roger Bacon in 1237, in his for-

mula for "making thunder and lightning," are still in use, and in nearly the same proportion now as at that early date. The three solid substances which, when properly and intimately mixed, form gunpowder, are saltpeter, sulphur, and charcoal; the first being three fourths, or a little more, of the mixture, the two latter, in nearly equal but varying proportions, forming the remaining one fourth. The saltpeter contains a large amount of oxygen, which it gives up with considerable readiness upon the application of heat; this unites with the carbon contained in the charcoal, forming a large volume of carbonic-acid gas; the potash of the saltpeter unites with the sulphur, while the nitrogen is set free, adding to the volume of the gases evolved. As these gases are given off with great rapidity, they are still further expanded by the action of the heat produced by the change of the solids into the gaseous form, until, under ordinary circumstances, they occupy a volume nearly three hundred times as great as that occupied by the powder itself. One can easily imagine that the expansion of a pound of powder to a size (if we may so say) so much greater than its original bulk would exert a tremendous pressure upon any object in which it was confined. If a small quantity of powder is freely exposed in the air and fired, the resulting explosive effect is small, as the gases produced so rapidly can readily push aside the air; but if it be confined in a large block of steel, in which is a cavity which will just receive it snugly, the resulting pressure is nearly ninety-three thousand pounds to the square inch.

From this illustration it will at once be understood that confinement, in a greater or less degree, is necessary, in order that the greatest amount of work may be accomplished by the explosion. Those explosives which give off their gases with intense rapidity require but little restraint, while the slower ones require more confinement. Among these less quick ones must be reckoned gunpowder, for, although the explosion seems to follow immediately upon the application of heat, yet an appreciable amount of time really elapses, in which the combustion goes on.

The ingredients of which gunpowder is composed are selected with the greatest possible care: the saltpeter is procured chiefly from India, being extracted from the soil by natural processes and then secured by the natives, for marketing. It is also largely prepared by artificial means, it being quite evident that it would not do for any country to depend upon a supply without its own borders in case of war. In this process, heaps of earth are mixed with decomposing organic matter—ashes, old mortar, and materials of like nature—the whole being wet with the liquor from stables sufficiently to keep it in a moist condition; the moistened heaps are worked over from time to time, and the air allowed free access. A chemical reaction takes place, and in time the crude saltpeter appears upon the exterior of the heap, whence it is removed and treated for the extraction of the pure

material. Both the India and the artificial products are mixed with hot water, which takes up the salts, leaving the earthy matters behind; this liquid is then evaporated, the saltpeter crystallizing as a fine white powder; if the original be very crude, this product is again subjected to a similar process.

The charcoal requires more care in its preparation than either of the other ingredients, as upon its quality depends largely the violence of the action of the powder; the more nearly pure carbon it is, the better will be the result. It is made from some very light wood, such as the black alder or willow, as these contain much carbon, and but little ash: small pieces of these woods, stripped of their bark, are placed in a retort which is kept at a uniform heat; the vapors are allowed a free exit, and the roasting is kept up until the experienced eye of the workman warns him that it is time to withdraw the charge, lest it be overburned. The entire contents of the retort are removed at once, and covered in air-tight drums, where the charcoal is left to cool. Thus prepared, charcoal is quite a different material from that in ordinary use; it being of a bluish-black tinge, somewhat elastic and slightly resonant when struck lightly with the finger, with the appearance of the woody fiber clear and distinct.

The sulphur is prepared from its ore, by roasting the latter in a retort, the vapors given off being condensed, and the resulting liquid run into molds, and allowed to harden.

Having procured the materials of proper fineness and in the desired proportions, the sulphur and charcoal are placed in a revolving cylinder with cylindrical rollers inside, by the action of which they are broken up into small pieces. These are then transferred to a similar cylinder containing bronze or zinc balls, in which they become very highly pulverized. When this is fully accomplished, the saltpeter is mixed with them, and the whole mass placed in the incorporating mill, being kept moist enough to be like dough, but still not too wet, as that would interfere with its proper mixture. This mill consists of two heavy iron wheels, revolving at the extremities of an horizontal axis, the whole being revolved about a vertical axis in the center of a cast-iron bed, surrounded with wooden sides. As this upright axis revolves, the wheels move about their own axes, having at the same time a forward motion, which causes the powder to be both mixed and pressed at the same time; in this manner, the mixture is rendered much more intimate than by the old method of stamping, in which the ingredients were placed in huge wooden mortars, and subjected to the action of heavy pestles of the same material. When sufficiently mixed, the mill-cake, as it is then called, is allowed to dry; after which it is taken to the breaking-down machine, where, on passing between heavy wooden rollers, it is broken into small fragments. The next step is to subject it to the action of the press; this is an horizontal wooden trough in which are placed (about an inch and a

half apart) accurately fitting sheets of hard rubber; the crushed powder is shoveled into the trough, and a powerful hydraulic press applied; a screw-press would be dangerous, as particles of powder might get into the thread of the screw, and be fired by the friction. When removed from the press, the powder is in slabs of close texture, not unlike slate in appearance. These slabs go next to the granulator, in which they pass through a series of rollers, separated by sieves; as the broken powder passes from one set of rollers to the succeeding one, the sieves are kept in constant agitation, the pieces which pass through them falling to the bottom of the machine, where they are collected. Each sort is then taken to a rotating reel of wire gauze, in which, as it revolves, the dust is removed. If the powder is to be glazed, the clean grains are placed in a slowly revolving drum, with a very small quantity of plumbago, or black-lead; if glazing is not required, as is the case with some sorts of powders, the same process is gone through, the black-lead being omitted; in this manner, the grains are rounded off, and rendered smooth.

The final step is the drying, which is done in a steam-heated house, the powder being spread upon shelves for this purpose. The finished product is placed in oak kegs fastened with copper hoops, and care is always enjoined to use no iron tool in opening them. These various operations are conducted in buildings situated at a distance from each other sufficiently great to prevent the explosion of one causing that of another; they are generally placed along the banks of some stream from which the requisite power for operating the machinery can readily be obtained.

The manner in which the powder burns is greatly affected by variations in its manufacture: the greater the size of the grains, the more slowly does the burning take place, as the combustion goes on upon the surface, particle by particle; the shape of the grain regulates the amount of space taken up by the charge, as also in some degree the amount of surface exposed to the action of the flame; the density (depending upon the amount of pressure applied to the press-cake) also affects the rapidity of the burning; the lower the density, the more quickly does the combustion take place.

A desire to reduce the strain upon the walls of the modern guns has led to many experimental trials of various sizes and shapes of grain; the principal credit for these ideas is unquestionably due to an American ordnance-officer, Rodman. Much care has been taken in this regard, and we now see much higher velocities given to projectiles than heretofore, with, at the same time, less strain upon the gun.

There are various other mixtures which are explosive in their character, but their use is prevented by various considerations, chiefly by the fact of their greater sensitiveness to friction or percussion, and their consequent greater danger, or by their corroding effect upon the metal of which the gun is constructed. A powder which might prove

to be useful where a stronger explosive than ordinary gunpowder is desired is known as Abel's picric powder; this is a mixture of picrate of ammonia and saltpeter, prepared in an ordinary powder-mill by the processes just detailed. Picric acid (by means of which the picrate of ammonia is obtained) is derived from the action of strong nitric acid upon carbolic acid. This powder requires confinement to develop its force, is not exploded by friction, and, as it absorbs no moisture by exposure to the air, can be used and stored like gunpowder; for the ordinary uses of gunnery, however, it can never supersede its elder brother.

As has already been said, gunpowder burns, rapidly it is true, but nevertheless the action is a true combustion. We now come to the consideration of a new class of explosives, which do not burn, but resolve themselves into their constituent gases immediately upon the application of the force which suffices to bring about their disintegration. These are not mixtures like gunpowder, but definite chemical compounds in which the carbon, oxygen, and hydrogen are held a little way apart, as it were, by the nitrogen, but ready to rush together at the first opportunity; the explosion of one particle means generally the contemporaneous explosion, or detonation, of the whole mass: with such bodies confinement to any great extent is not necessary.

Pre-eminent among these detonating substances for its use in mining and engineering operations of a like character stands the compound known as nitro-glycerine. This is manufactured in greatly increasing quantities in many places, both in this country and in Europe, and its use for the purposes above mentioned is becoming more and more general. Its transportation in the liquid state being excessively dangerous, it was for a long time but little used; but, it having been ascertained that it can be mixed with other materials and carried with comparative safety, its field of usefulness has become greatly enlarged. It is formed by the action of very strong nitric acid upon glycerine at a low temperature, the resulting product being removed and washed free of its impurities.

Glycerine is a by-product of the stearine-candle manufacture, being separated from the stearic acid contained in animal fat upon the application of superheated steam. It is subsequently redistilled until its impurities are removed, in which condition it is proper to be used in the manufacture of nitro-glycerine. Unfortunately, however, many manufacturers do not restrain themselves to a pure quality of the glycerine, but, using inferior ones (which are, of course, cheaper), make a nitro-glycerine which is of a much more dangerous character than should ever be used.

The process of manufacture is as follows: The nitric acid is mixed with twice the quantity of sulphuric acid, and both then mixed with the glycerine; the nitric acid acts upon the glycerine, leaving a quantity of water free; were the sulphuric acid not present, this water

would dilute the nitric acid, but, as the sulphuric acid has a greater affinity for water, it takes it up, leaving the other of its normal strength. To proceed to the details: Around a brick chimney is placed a wooden trough, containing large earthenware pitchers in which is the acid mixture, the trough being filled with ice. On a shelf above this trough are placed bottles holding glycerine, communicating each with a pitcher below, by means of a small rubber tube, so arranged as to permit the passage of the liquid in a fine stream. The contents of the pitchers are kept in a constant state of agitation by a stream of cold dry air forced through them; as the reaction between the nitric acid and the glycerine goes on, great heat is evolved, accompanied by nitrous fumes extremely unpleasant and unhealthy to inhale; these fumes are drawn into the chimney through an overhanging hood, by means of the draught created by a furnace-fire at the bottom. Great care is necessary that the temperature be not allowed to rise above 48° Fahr., as there would then be danger of the newly formed nitro-glycerine taking fire and exploding; constant attention must be paid to this point, each pitcher being tried with a thermometer at short intervals. The proportion of materials is about two pounds of glycerine to twenty pounds of the acid, and at the expiration of the process the glycerine and nearly all the nitric acid have disappeared, forming nearly four pounds of their compound; the sulphuric acid, diluted as before mentioned, also remains. The nitro-glycerine is now partly in solution and partly suspended in the acid mixture; the contents of the pitchers are poured through a strainer into a vat of water, which is kept in agitation by a stream of compressed air: after all the pitchers are emptied, the air is shut off and the mixture comes to rest, when the nitro-glycerine settles at the bottom of the vat, and the acid water is then drawn off. It is next taken in small quantities at a time, and carefully washed a number of times, until all the acid is washed out, and only the pure nitro-glycerine remains; in this state it is thin, oily, creamy white, and opaque, but, on being placed in jars and allowed to stand, it soon becomes transparent. It is now ready for use as an explosive agent; it has a sweet, aromatic, pungent taste, and possesses the very peculiar property of causing an extremely violent headache when placed in a small quantity upon the tongue, or any other portion of the skin, particularly upon the wrist. It has long been employed by homœopathic practitioners as a remedy in certain kinds of headaches. In those who work much with it, the tendency to headache is generally overcome, though not always. It freezes at about 40° Fahr., becoming a white, half-crystallized mass, which must be melted by the application of water at a temperature of about 100° Fahr. If perfectly pure—that is, if the washing has been so complete as to remove all traces of the acid—it can be kept for an indefinite period of time; and, while many cases of spontaneous decomposition have occurred in impure specimens, there has never been known such an instance,

where the proper care has been given to all the details of the manufacture.

There are other methods of manufacture, differing, however, only in the details, the principle of course being the same.

When pure, nitro-glycerine is not very sensitive to friction, or even to moderate percussion : if a small quantity be placed on an anvil and struck with a hammer, that portion which is touched explodes sharply, but so quickly as to drive away the other particles ; if, however, it were even slightly confined, so that none could escape, it would all explode or detonate. It must be fired by a fuse containing fulminate of mercury (the compound used in percussion-caps), not being either readily or certainly fired by gunpowder, the shock of the latter not being sufficiently quick or sharp to detonate the nitro-glycerine. It is highly probable that in this case, as in that of other high explosives, the vibrations set up by the fulminate (which is not stronger than gunpowder) are of just such a character as to find an answering chord, so to speak, in the explosive, so that the desired effect is produced. This would seem to be a correct theory, for it is not always the most powerful explosive which most readily causes the explosion of another body. For instance, although nitro-glycerine is much more powerful than fulminate of mercury, yet seventy grains of it will not explode gun-cotton, while fifteen grains of the weaker fulminate will readily do so. The fuse generally used, then, for firing nitro-glycerine, is composed of from fifteen to twenty-five grains of fulminate, and this quantity is sufficient to detonate a large mass as well as a small one.

If flame be applied to nitro-glycerine it will not explode, but burn with comparative sluggishness. When frozen it is very difficult and uncertain of firing. If the material be perfectly pure, it forms, upon detonation, a volume of gases nearly thirteen hundred times as great as that of the original liquid ; these gases are also further expanded, by the heat developed, to a theoretical (though not practical) volume ten thousand times as great as that of the charge. Practically speaking, the forces exerted by gunpowder and nitro-glycerine are in the proportion of one to eight.

The great objection to nitro-glycerine, in its liquid state, is the difficulty of its transportation ; it is liable to leak from the packages in which it is contained, and there have been several occasions on which disastrous accidents have taken place owing to this circumstance. The explosion of a large case on board of a steamer in Aspinwall some twelve or fourteen years ago, and, about the same time, of a box in an express-office in New York, caused great precautions to be taken with regard to it, and also very great fear of it on the part of all transportation companies. Fortunately, it has been found that it can be carried from place to place by mixing it with some absorbent substance, which takes up a large quantity of it ; it is just as powerful in this state, the presence of the absorbent having no deleterious effect. This

mixture is called dynamite, or giant-powder; it is made by mixing nitro-glycerine with a siliceous earth, in the proportion of three to one by weight. This earth is a fine white powder, composed of the skeletons of microscopic animals; it is found in Hanover and also in New Hampshire—that coming from the latter locality being the finer, and therefore most used in this country. The dynamite formed by this mixture is not unlike moist brown sugar in appearance; care must be taken not to put too much nitro-glycerine in it, as there must not be such a quantity as would cause exudation. Its properties as an explosive, are, of course, those of the nitro-glycerine alone; but it can be much more readily handled, and there is less danger from either percussion or friction. It has been dropped from a height upon rocks, heavy weights have been allowed to fall upon it, and other experiments of a like nature have been made to show how readily it can bear transportation and hard knocks. This safety, however, presupposes a pure nitro-glycerine; and whenever an accident occurs it may safely be laid to the impurity of the explosive, and not to anything necessarily consequent upon the use of dynamite. Under the action of cold, dynamite freezes at 40° Fahr. in a hard, compact mass, in which condition it is very difficult to explode. Sometimes, however, it freezes in a loose and powdery state, and there is then no difficulty in causing its explosion with the ordinary fulminate-fuse. Generally speaking, however, it is best with this, as with nitro-glycerine, to thaw it out before attempting to use it. Instances have been known of careless men attempting to do this with a red-hot poker, with consequences, naturally, of a disastrous character. It will admit of being slightly moistened without injury, and hence can be used when gunpowder could not be. As a military explosive for mines and torpedoes, as also for the breaking up and destruction of guns, it has proved itself useful; and it has been used as a bursting-charge for shells, though this is considered dangerous.

Besides dynamite, there are several other mixtures of nitro-glycerine, in which the inactive siliceous earth is replaced by some active substance, such as charcoal, saw-dust, wood-fiber treated with acid, chlorate of potash, or even gunpowder. It is extremely doubtful whether anything is added to the explosive effect of the nitro-glycerine by their presence, as its own explosion is so rapid as to gain nothing from the slower combustion of these substances. Experiments with the pressure-gauge tend to show the correctness of this theory. Of all these combinations, that called cellulose dynamite is the best; it is a combination of the wood-pulp, so much used for the manufacture of paper, treated with nitric acid and nitro-glycerine; it possesses the excellent quality of being able to absorb a considerable quantity of water without injury; for this reason it may prove itself a commercial rival to dynamite pure and simple.

Large quantities of dynamite are manufactured in this country for

use in mining and engineering operations; among others, the Hoosac Tunnel and the works at Hallett's Point in New York harbor undoubtedly owed much to the powers of nitro-glycerine in hastening their completion. The effect of a confined charge upon rock is to pulverize the portion near the blast-hole, the action being so sudden, quick, and intense; it is, therefore, found better not to tamp the hole, a saving both of time and labor, allowing the gases a greater surface upon which to act. Ordinarily the dynamite is contained in paraffined paper cartridges, and is fired with a fulminate-fuse.

Gun-cotton is formed by the action of nitric acid on cotton—a portion of the hydrogen being displaced in the cotton, just as it is in the glycerine by the active constitution of the nitric acid. The essential features of the process are the same as those of the manufacture of nitro-glycerine; that is to say, a mixture of strong nitric and sulphuric acids is made, the cotton exposed to its action, and the excess of acid removed from the cotton by careful washing; the sulphuric acid plays the same part, namely, that of taking up the water formed, and so keeping the nitric acid at its full strength. As in the former case, only perfect purity will insure safety; the presence of acid in the gun-cotton will ultimately cause decomposition and explosion. Many accidents have taken place since the introduction of gun-cotton to public notice some thirty-five years ago; but, as in the case of nitro-glycerine, all of them may be ascribed to imperfect washing, reference being had, of course, to instances of what may be called spontaneous combustion. With the improved methods of to-day, however, and the exercise of ordinary care, gun-cotton can be rendered perfectly stable and safe, far safer for transportation than nitro-glycerine in any of its forms; when wet it can not be readily exploded, and hence it is generally carried in that state, and either dried for use or else exploded by the use of a dry primer of the same material. It possesses, however, the disadvantage of rapidly absorbing moisture, and hence it is extremely difficult to keep primers dry unless they are prepared with great care. In a military point of view this is no great objection, but commercially speaking it is, for the expensive water-proof cases would perhaps make its use financially impracticable.

The details of the usual process of its manufacture are as follows: cotton-waste is picked and cleaned, then dried at a high temperature. After cooling, in quantities of about a pound, it is immersed in the strong acid mixture contained in a trough surrounded by cold water; after a short exposure it is removed, and the acid pressed from it as far as practicable. After another immersion of twenty-four hours, it is placed in a centrifugal strainer, by the rapid revolutions of which nearly all the acid is expelled; it is then washed in a large amount of water, and again placed in the strainer. When the acid-water no longer remains, the gun-cotton is placed in the pulper, an oblong tub

full of water, in which revolves a wheel having strips of steel upon its rim, similar strips projecting from the bottom of the tub. As the wheel revolves, the floating pieces are drawn between the steel strips and thus reduced to a fine pulp. This is again washed for a long time by mechanical means, after which it is taken to the press, where nearly all the water is expelled from it, the final pressure applied being about fifteen thousand pounds to the square inch. When taken from the press, it is in the shape of a disk or cylinder, of a close texture, easily broken when dry, and capable of being cut in a manner not unlike pasteboard. When a small quantity is ignited by a flame, it burns quite rapidly, but quietly, if dry; if wet, it is consumed very slowly. If a large quantity is ignited, there may be sufficient confinement of the inner portions by the outer shell to cause an explosion. If dry loose gun-cotton be ignited, it burns with extreme rapidity, like a flash, but without any violence; in fact, a wisp placed on a small pile of gun-powder and fired will not ordinarily cause its explosion. In order to have a complete explosion of the dry material, fulminate of mercury must be used, and this is accordingly employed in the primers made for the explosion of that which is wet. Two pounds of the dry, detonated by twenty-five grains of fulminate, will cause the detonation of five hundred pounds of the wet. In this wet state it must be carefully guarded from a low temperature, as the expansion of the water in freezing will tend to break up the disks.

Many experiments have been made with a view to its adoption in gunnery practice, but it is not at all likely that either it or any of the high explosives will ever displace gunpowder; their action is so violent and sudden that, before the projectile has time to take up its motion in the bore of the gun, the walls yield and the piece is burst. Its use for military purposes must therefore be confined to mines and torpedoes, as in the case of dynamite, or as a bursting-charge for shells, for which purpose experiments show that it is most admirably adapted. It is used in Europe for torpedo purposes, and is carried for that use by war-vessels of the English and other navies.

The explosive gun-cotton is not the only kind made; another sort (in which a less amount of the hydrogen of the cotton is displaced) is used for making collodion, largely employed by photographers. This variety, called collodion gun-cotton, combined with nitro-glycerine, forms a new explosive agent called gum-dynamite, or explosive gelatine. Singular to relate, the ordinary gun-cotton used for explosive purposes will not enter into this combination, and hence probably the late discovery of the fact that it requires the collodion variety to do so. This is finely shredded, generally by hand, and placed in small quantities at a time in the nitro-glycerine, which is kept at a temperature of 80° Fahr. by means of a water-bath, the whole being constantly stirred with a wooden spatula; the proportion of materials is seven per cent by weight of the gun-cotton to ninety-three per cent of the nitro-glycerine.

The latter dissolves the former, and the result is an elastic, gelatinous, semi-transparent mass, which is easily cut or torn apart, and shows no trace whatever of nitro-glycerine on handling. Its explosive properties are unaffected by contact with water, and in this respect it is the most useful of all the high explosives for military purposes. With the change in the physical condition of the two components comes also a change in the ease of explosion; these two bodies, each of itself highly explosive, form when united one which is quite the reverse. When unconfined, a primer of fifty grains of fulminate will cause the explosion of but a very small portion of a charge, the rest being torn in pieces; if, however, it be strongly confined, so that the blow of the fulminate exerts its whole force, which is propagated through the gelatine, it then explodes with a violence as great as that of nitro-glycerine, if not somewhat greater. This latter point has not been fully determined, but the probabilities are that the expansion of the constituents of the gelatine is more complete and is accompanied with more heat than is the case with nitro-glycerine alone. The gelatine freezes at 40° Fahr., and in this state is fired with no difficulty whatever, being in this respect much superior to dynamite. When subjected to a pressure of two hundred and fifty pounds to the square inch, no nitro-glycerine is separated; the union between the two constituents seems to be complete and definite. If subjected to the action of flame, it takes fire less readily than dynamite, but burns very much like it, with perhaps a greater strength of flame, as if urged by a bellows. When heated to 100° it softens, but does not become at all greasy, and there is no exudation of nitro-glycerine. Explosion by the application of heat takes place at about 420°; but it is found that by the addition of a small amount of camphor, say four per cent, it will bear an increased heat of 100° before explosion. Experiments made with the gelatine thus camphorated show that the camphor exercises no deleterious effect upon the strength of the material, while rendering it less like jelly, and more like that form of confection known as fig-paste. Six per cent of camphor may be added without harm, but any greater quantity materially diminishes the explosive effect. Portions of this gelatine, both pure and camphorated, have been subjected to a constant heat of 100° for more than six weeks, and no exudation of the dangerous nitro-glycerine has been observed. It will not explode under circumstances which ordinarily render certain the detonation of either nitro-glycerine or dynamite—that is to say, a quantity of the gelatine will resist the shock of the detonation of another quantity placed within a very few feet of it; if very near, it may take fire and burn, but detonation will not ensue unless the two masses are almost in actual contact, and even then it will not always occur. It further possesses the property of permitting the impact of a ball from a gun without exploding, while both dynamite and gun-cotton may be readily detonated by a blow of this kind. All

these tests tend to show that it possesses in a high degree the elements desired in the ideal high explosive for military purposes, if not for commercial use.

So much difficulty was encountered in the first attempts at the construction of a suitable primer for its explosion, that it seemed doubtful whether it would ever be a practicable material, as it was thought that nitro-glycerine must be used to accomplish the desired result. Subsequent experiments conducted in this country have shown, however, that a dry gun-cotton fuse with a fulminate cap containing twenty-five grains will fire the gelatine with ease and certainty, even when unconfined. The problem so long confronting the manufacturer of explosives would seem to be nearly solved: the requisites of great power in small compass, of permanency when subjected to tropical heat, of ease of firing when but slightly confined, of safety from the explosion of neighboring masses of the same or on being struck by a projectile, and of not being affected injuriously by water, all seem to be fulfilled by this agent in a manner more complete than by any other.

If it should be found that a long-continued exposure to heat tends to produce decomposition, as may prove to be the case, greater care in the preparation of the materials from which it is manufactured will probably overcome this difficulty, and it will then bid fair to supersede gun-cotton for very many purposes, if it does not altogether take its place.

Constant allusion has been made to the use of fulminate of mercury as an agent for the firing of other explosives. It is prepared by dissolving mercury in nitric acid, and then mixing this solution with alcohol, in a vessel placed in a hot-water bath. Dense white fumes soon arise from the agitated liquid, until finally, the disturbance having subsided, the bottom of the vessel is found covered with a gray powder, which is afterward thoroughly washed. This gray powder is the fulminate used in the caps and cartridges familiar to sportsmen, as well as in the primers for cannon and the fuses for the explosion of a quantity of gunpowder or other explosives. Being harmless when wet, it is usually kept and handled in that condition. Generally speaking, electricity is the agent by means of which the fulminate is ignited; the fuse for this purpose is ordinarily constructed as follows: A brass or copper cylinder, about half an inch in diameter, closed at one end, is partially filled with the desired quantity of the wet fulminate; when this has become thoroughly dry, a wooden plug closing the entrance is inserted; in this plug are two holes, through each of which passes an insulated copper wire with bared ends, which project a short distance above the surface of the plug and are connected by a very small wire composed of an alloy of platinum and silver; around this wire, or bridge, as it is called, is twisted a small wisp of dry gun-cotton, which, when the plug is in place, comes in contact with the ful-

minate. After the insertion of the plug, the whole fuse is dipped in some water-proof composition and thoroughly dried. In use, the wires are connected with other wires leading from a galvanic battery or an electrical machine; when the current is caused to pass through these wires it reaches the bridge, where meeting with greater resistance to its progress, it raises the platinum wire to a heat sufficient to ignite the gun-cotton wisp, which in turn ignites the fulminate. It will be seen that in all cases it is absolutely necessary to keep the ultimate explosive dry, as even those high explosives which are not themselves affected by water require the use of perfectly dry primers. The orders of Cromwell must still be obeyed—to "trust in God, and keep your powder [or primers] dry."

THE UTILITY OF DRUNKENNESS.

By W. MATTIEU WILLIAMS.

IN the early argumentative struggles between the advocates of total abstinence from alcohol and their opponents, the latter believed they settled the question by affirming that "these things are sent for our use," and therefore that it was flying in the face of Providence to refuse a social glass. This and many similar arguments have subsequently been overturned by the abstainers, who have unquestionably been victorious "all along the line," especially since Dr. B. W. Richardson has become their commander-in-chief.

In spite of this, I am about to charge their serried ranks, armed with an entirely new weapon forged by myself from material supplied by the late Dr. Darwin, my thesis being that the drunkenness which prevails at the present day is promoting civilization and the general forward progress of the human race.

Malthus demonstrated long ago that man, like other animals, has a tendency to multiply more rapidly than the means of supporting his increasing numbers can be multiplied; he and his followers regarded this tendency as the primary source of poverty and social degradation. Darwin, starting with the same general law, deduces the very opposite conclusion respecting its influence on each particular species, though his antagonism to Malthus does not prominently appear, seeing that his inferences were mainly applied to the lower animals. Darwin shows that the onward progress, the development, or what may be described as the collective prosperity of the species, is brought about by over-multiplication, followed by a necessary struggle for existence, in the course of which the inferior or unsuitable individuals are weeded out, and "the survival of the fittest" necessarily follows; these superior or more suitable specimens transmit more or less of their advan-

tages to their offspring, which, still multiplying excessively, are again and again similarly sifted and improved or developed in a boundless course of forward evolution.

In the earlier stages of human existence, the fittest for survival were those whose brutal or physical energies best enabled them to struggle with the physical difficulties of their surroundings, to subjugate the crudities of the primeval plains and forests to human requirements. The perpetual struggles of the different tribes gave the dominion of the earth to those best able to rule it; the strongest and most violent human animal was then the fittest, and he survived accordingly.

Then came another era of human effort gradually culminating in the present period. In this, mere muscular strength, brute physical power, and mere animal energy have become less and less demanded as we have, by the aid of physical science, imprisoned the physical forces of nature in our steam-boilers, batteries, etc., and have made them our slaves in lieu of human prisoners of war. The coarse muscular, raving, yelling, fighting human animal that formerly led the war-dance, the hunt, and the battle, is no longer the fittest for survival, but is, on the contrary, daily becoming more and more out of place. His prize-fights, his dog-fights, his cockpits, and bull-baiting are practically abolished, his fox-hunting and bird-shooting are only carried on at great expense by a wealthy residuum, and by damaging interference with civilized agriculture. The unfitness of the remaining representatives of the primeval savage is manifest, and their survival is purely prejudicial to the present interests and future progress of the race.

Such being the case, we now require some means of eliminating these coarser, more brutal, or purely animal specimens of humanity, in order that there may be more room for the survival and multiplication of the more intellectual, more refined, and altogether distinctively human specimens. It is desirable that this should be effected by some natural or spontaneous proceeding of self-extinction, performed by the animal specimens themselves. If this self-immolation can be a process that is enjoyable in their own estimation, all the objections to it that might otherwise be suggested by our feelings of humanity are removed.

Now, these conditions are exactly fulfilled by the alcoholic drinks of the present day when used for the purpose of obtaining intoxication. The old customs that rendered heavy drinking a social duty have passed away, their only remaining traces being the few exceptional cases of hereditary dipsomania still to be found here and there among men and women of delicate fiber and sensitive organization.

With these exceptions, the drunkards of our time are those whose constitutions are so coarse, so gross and brutal, that the excitement of alcoholic stimulation is to them a delicious sensual delirium, a wild

saturnalia of animal exaltation, which they enjoy so heartily that every new raving outbreak only whets their appetite for a repetition. While sober they actually arrange and prepare for a forthcoming holiday booze; work and save money for the avowed purpose of purchasing the drink and its consequent ecstasies, which constitute the chief delights of their existence. When a professional criminal has "served his time," and is about to be released from prison, his faithful friends club together to supply him with the consolation of an uninterrupted course of intoxication; the longer its duration the greater his happiness, and the deeper his obligations of gratitude to the contributing "pals."

We know that such indulgence has swept away the Red Indian savage from the American Continent, and prepared it for a higher civilization, as the mammoth and grizzly bear have made way for the sheep and oxen; and this beneficent agent, if allowed to do its natural work, will similarly remove the savage elements that still remain as impediments to the onward progress of the more crowded communities of the Old World. If those who love alcoholic drinks for the sake of the excitement they induce are only supplied with cheap and abundant happiness, our criminal and pauper population will be reduced to a minimum.

It is commonly supposed that, because nearly all criminals are drunkards, therefore drunkenness is the chief cause of crime. This is a confusion of cause with effect. Crime and drunkenness go together because they are concurrent effects of the same organization. Alcoholic stimulation merely removes prudence and brings out true character without restraint or disguise. The brute who beats his wife when drunk would do so when sober if he dared and could; but what we call the sober state is with him a condition of cowardly depression and feebleness due to the reaction of intoxication. If a number of quarrelsome men assemble and drink together, they finish with fighting. If a similar number of kindly disposed men drink together, they overflow with generosity, profuse friendliness, and finally become absurdly affectionate. The citizen who would have subscribed but one guinea to a charity before dinner will give his name for five after the "toast of the evening."

My general conclusion is that all human beings (excepting the few dipsomaniacs above-named), who are fit to survive as members of a civilized community, will spontaneously avoid intemperance, provided no artificial pressure of absurd drinking customs is applied to them, while those who are incapable of the general self-restraint demanded by advancing civilization, and can not share its moral and intellectual refinements, are provided by alcoholic beverages with the means of "happy dispatch," will be gradually sifted out by natural alcoholic selection, provided no legislative violence interferes with their desire for "a short life and a merry one."—*Gentleman's Magazine.*

DELUSIONS OF DOUBT.

By M. B. BILL.

I PROPOSE to describe an extremely curious form of mental alienation which does not often occur, except among subjects whose minds have received a certain degree of culture, and the victims of which are seldom consigned to the asylum. It is an affection the subjects of which nearly always belong to the category of free eccentrics. I refer to the singular perturbation of mind which has been described by the elder Falret as the doubting disease (*maladie du doute*); by the younger Falret as partial insanity, with dread of the touch (*crainte du contact*) of exterior objects; by Oscar Berger as *Grübelsucht*, or the mania for subtilties; and by Legrand du Saulle as the folly of doubt, with delirium of the touch (*folie du doute avec délire du toucher*).

Waiving for the present the consideration of the tactile element, we might, perhaps, designate this mental state, which is always accompanied by consciousness, by the name which has frequently been given it of "metaphysical delirium." The case is really one of a morbid condition that is variable in its manifestations and which deserves, according to the particular forms in which it exhibits itself, all the names that have been given it. One patient, for example, will doubt everything, even his own existence, and will not be able to fix himself to any formal conviction. Another will manifest, besides this psychological state, a real fear of the contact of exterior objects. Another will feel a constant inclination to split hairs into quarters, and to exhaust all the subtilties of the ancient scholastics upon the most frivolous and trite subjects. All of these conditions, apparently so different, are brought together by one characteristic trait of intellectual restlessness.

"The true basis of this mental disease," says M. J. Vallent, in his "De la Folie Morale," "is a general disposition of the intellect to return continually upon the same ideas or the same acts, to feel a continuous necessity for repeating the same words or performing the same actions, without ever satisfying itself, or being convinced even by evidence. I have described certain phenomena of this order under the name of intellectual impulsions. I give a curious example of them. A young collegian, who had previously been very regular in his habits, was present at a party where some of his friends were jesting about the fatal influence attributed to the number thirteen. Suddenly an absurd thought occurred to him that, if thirteen was an unlucky number, it would be deplorable if God were thirteen, space thirteen, infinity thirteen, and eternity thirteen; and, to forefend such a woe, he every instant formulated in his mind an ejaculatory prayer thus conceived:

'God thirteen!' or else, 'Infinity thirteen! eternity thirteen!' Yet he was perfectly accountable, for he wrote to me himself that it was absurd to figure God as thirteen for an instant, to prevent his ever being it. But, pursued by this incessantly returning obsession, he kept on repeating his mental prayer at every instant, and ended with not being able to continue his studies, or to devote himself to any serious occupation."

We come now to the history of a patient whose case I have especially in view, who presents to us an example of the delirium in its purest, most elevated, and most metaphysical form, and least complicated with any foreign element. He is a young man of about twenty-eight years, of an agreeable and intellectual appearance and a fine physical development. He is the fifth son of his father, who is still living, and has no other infirmity than a light trembling. No hereditary vice exists in his family, but the patient had convulsions in his infancy, the last of which occurred when he was eight years old; since then he has had no other sickness. The normal soundness of his development is proved by the fact that he is now the support of his family. He is employed in a bank, and his services are much appreciated there. He is very intelligent, but has never received any but a rudimentary education. He has never read Descartes nor the other philosophers, and, when he involuntarily touches upon the most abstruse questions, it may be said that he makes metaphysics without knowing it. He was working diligently and regularly at his desk in the bank, when, one morning in June, 1874, he observed a sudden and curious change occur in the appearance of objects, concerning the nature of which I can not give a clearer idea than by repeating his own description of his impressions:

"In the month of June, 1874," he writes, "I felt quite suddenly, without any pain or giddiness, a change in the aspect of my vision. Everything seemed to me strange and queer, although the same forms and colors were preserved. Under the mistaken thought that the disagreeable sensation would pass away as it had come, I gave myself no more trouble about it, till a polypus made its appearance in my left nostril. I then went to a doctor and had him remove the polypus, without telling him anything about the new state of my vision. I thought the polypus was the cause of the strange appearance things presented to me, and that, when it was taken away, I would be all right again. But nothing of the kind came to pass. No remarkable change occurred till December, 1880, more than five years afterward, when I felt myself diminishing, and finally to disappear. Nothing was left of me but an empty body. From that time my personality has wholly vanished, and, in spite of all that I can do to get back that self that has escaped, I can not. Everything around me has become more and more strange; and now, not only do I not know what I am, but I can not give any account of what is called existence, reality.

What is it that has happened? Does everything around me really exist? What am I? What are all these things that are made like me? Why am I? Who am I? I exist, but outside of real life, and in spite of myself. Nothing, however, has given me death. Why are all these things around me which all present the same aspect? These things should enjoy life. What are these things?

"Although in this cruel condition, I have to do as I did before, and, without knowing why, something that does not appear to reside in the body urges me to continue as formerly; and I can not realize that this is true, that I really act. Everything is mechanical with me, and done unconsciously.

"When I experience a physical sensation, the substance that produces it, which is without any significance to me, is a blank. I feel a pressure on my temples and a stress between my eyes at the top of my nose, with a twitching of the nose to the top of my forehead. My ears hear well, but appear stopped up. My left nostril is sometimes obstructed, then free, then closed. Besides this strange sensation I remark that when any one speaks to me I answer immediately, and the answer is a reasonable one.

"My work has so far been done properly and without any mistake; and yet, when I say to myself, as I am saying continually, 'I am doing this, I am doing that,' I can not bring myself to realize that it is true.

"I may describe my condition in brief by saying that my personality has wholly disappeared; it seems to me that I have been dead for two years, and that the thing that exists does not recall anything that has a relation with any former myself. The manner in which I see things does not give me any realization of what they are, or that they exist, whence the doubt, etc.

"In view of this painful mental condition I come to ask you now whether I am not about to become mad, or whether I can do anything to deliver myself from a disorder which has continued so long, and which has so far only been modified. Without being able to enjoy life in any way, for I do not comprehend it, I am obliged to suffer everything that others, who are in their normal state, suffer."

The dominant fact in the psychological condition of this man is the absolute loss of the sentiment of reality. He compares himself to an empty paper sack. There is nothing in him. Nothing is left of him but an envelope which preserves a kind of external appearance, but which is in fact perfectly empty. He calls himself "a thing." Other men are "things" like him, but he does not believe in their real existence. He does not believe in what he sees, and when he puts out his hand to touch any object he is convinced in advance that he will find nothing but a phantom that will vanish. Although he really touches the object, the tactual added to the visual impression is still not enough to overcome his incredulity. The world, in his eye, is nothing

but a gigantic hallucination. He continues, in the mean time, to exercise the different functions of life. He eats, but it is a shadow of food that enters a shadow of a stomach; his pulse is only a shadow of a pulse. He is perfectly conscious of the absurdity of his ideas but can not overcome them. Along with this profound intellectual trouble the physical functions have remained perfectly normal. He complains of nothing but a slight pressure on his temples, and about the root of his nose. Deeply sensible of his moral condition, he is afraid he is going mad, and comes of his own accord to ask for a place in an asylum for the insane.

Facts of this kind have been known for a long time. Examples of them may possibly be found in antiquity, but the first authentic observation of one is given by Esquirol. He tells of a young woman brought up in trade, who was tormented by a scrupulous fear of doing wrong to others. Whenever she drew up an account she was apprehensive of making a mistake to the prejudice of some other one. One day, coming out from her aunt's house which she visited frequently, she was distressed lest she might involuntarily carry off in her pockets something belonging to her relative. Then she began to take much time to verify her accounts and bills, for fear that she might commit some error and do wrong to purchasers. At a later stage she was afraid, when she handled money, that something valuable would remain in her fingers. It was of no use to tell her that she could not keep a piece of money without perceiving it, or that the contact of her fingers could not change the value of the money she touched. "That is true," she would reply; "my anxiety is absurd and ridiculous, but I can not help it." She had to withdraw from trade. Gradually her apprehensions grew till they domineered over her whole life. Yet she was reasonable, intelligent, and lively.

The subject has since been studied and examined in all its aspects by Parchappe, Trélat, Baillarger, the two Falrets, Delasiauve, Morel, and Marcé. M. Legrand du Saulle published a monograph on it, embodying the results of the labors of his predecessors, in 1875. My colleague, M. Ritti, has published an interesting study upon it in the "Gazette Hebdomadaire," and a very complete article in the "Dictionnaire Encyclopédique"; and Griesinger and Dr. Oscar Berger have published essays upon it in Germany.

Let us pass to the description of the doubting folly (*folie du doute*). The beginning of the malady is sometimes obscure, but it is rarely abrupt, as in the case we have noticed. Generally the patient, as in the observation of Esquirol, exhibits odd scruples; he attracts attention by his eccentricities, and becomes incapable of any kind of labor; he is afraid of compromising himself, reads and rereads what he has just written, and takes infinite precautions not to make a mistake. A doctor, afflicted with this folly, having carefully examined the patients who consult him, gave them prescriptions that he had compiled with

the greatest care; but no sooner had his patient left the office than he would run out to take the paper away, fearing that he had made a mistake, that he had prescribed a poisonous dose of some medicine, or had given some direction inconsistent with the symptoms.

The doubting folly assumes an infinite number of different forms. Without making an excessive use of subdivisions, we must establish a few categories.

We give the first place, in the order of dignity, to the metaphysicians. They are constantly preoccupied with the insoluble problems of philosophy. They are continually questioning about God, about the universe, about the creation of the world. They will ask themselves, Who created the Creator? They seek for the origin of language. They trouble themselves about the end of things, about the immortality of the soul; or, turning their attention to the physical universe, they endeavor to comprehend the phenomena of nature and the fluids that direct them. Our patient belongs to this category. The great object of his preoccupations is self, personality, the real existence of the objects of which he has a subjective perception. He reproduces without knowing it the ideas and often the expressions of the great philosophers who have cast the lead into these abysses. Next to the metaphysicians, we should place those whom I will call the realists. They are occupied with more or less trivial questions that do not permit any elevation of thought. A Russian prince, mentioned by Griesinger, wanted to know why men were not as large as houses; another patient, why the fire-place that warmed his room was fixed against the wall instead of being in the middle of the room; a third, why there was only one moon instead of two. Once started in this course, the patient attaches himself with a morbid tenacity to the most insignificant subjects, and they become for him the point of departure of an intellectual torture.

Next are the scrupulous, of whom Esquirol's patient offers a finished type. They are always reproaching themselves about everything, are tiresome with the precision of their speech, and are constantly afraid that they have not told the exact truth.

The timorous form a fourth class. They are people who, always afraid they will compromise themselves, are incessantly taking exaggerated precautions, and live in a perpetual disquiet. A woman, who was an artist and very intelligent, could never go into the street without a fear that some one would fall down from a window to her feet. She would ask what the consequences of such an accident would be, and saw herself already arrested and taken to prison under an accusation of homicide.

A fifth class, whose mania is really insupportable, are the counters. They are persons who, wherever they may be, are concerned with the number of objects. In the doctor's office, instead of being occupied with the subject of consultation, they are counting the buttons on the

doctor's coat, or the books on his table. M. Legrand du Saulle tells of a patient who would say, "Excuse me, it is involuntary, but I must count." Some celebrated men seem to have a similar mania. Dr. Johnson never omitted to step on every stone of the walk as he passed them; and, if by any chance he thought he had forgotten one, he would go back to touch it. Napoleon was in the habit of counting by pairs the windows as he went along the street. Other forms of this madness escape all classification. I have just seen a patient in whom an acute rheumatism has been followed by a special trouble of the will. If he is going into a house, or out of it, he experiences an invincible resistance at the door-sill, and he has to be urged before he can get over the obstacle. Sometimes, on the public road, he can not pass a tree or a stone. He is also persecuted by certain words, and when one of them gets into his head he repeats it through the whole day.

Some of these patients are described as being affected with an exaggerated fear of the contact of exterior objects. This is true. It has been attested by numerous observers, but the doubting folly can exist without such a complication, and our patient, who has no fear of the kind, is a proof of it. On the other side, the fear of contact may exist without the doubting folly.

A few additional characteristics will complete our view. The doubting folly is a conscious insanity. Persons afflicted with it are perfectly aware of their condition, and able of their own motive to put themselves under medical care. A second important characteristic is that persons afflicted with it seldom labor under hallucinations. When these occur it is the result of some other form of delirium which may be present in addition to this. A third characteristic is the perpetual desire the patients experience of having their doubts quieted by the affirmation of another person. A woman, cited by M. Ritti, was always afraid that she had said or done something reprehensible. If a person who could inspire confidence in her told her nothing of the kind had occurred, she immediately became calm again. A patient, who came to consult me, expressed doubts as soon as she entered my office as to whether I was really a doctor. Upon my answering that I was, she asked permission to inquire of the persons who were waiting in the parlor if I really exercised the medical profession. Sometimes patients of this class, after having solicited reassuring affirmations and having exhausted all the forms of question that imagination could suggest, add the demand, "Will you write it down for me?"

One of the most curious instances of this whim is related by M. Baillarger: A man about sixty years old had a passion, whenever he went to the theatre, for becoming acquainted with everything relating to the actresses he saw. He would want to know their age, their address, their family position, their ways of life, their habits, and their responsibilities. Tormented by this fixed idea, he had to deprive himself of the pleasure of going to the play. Soon, however, the

same idea manifested itself relative to all the women he met, provided they were pretty. He was obliged to have a person follow him, whose duty it was to satisfy him on this point. Every time he met a woman he repeated the eternal question, "Is she pretty?" The attendant would answer "No," and that would cut short the otherwise interminable series of his questions. One day he was starting by railroad for a distant point, and in his hurry forgot to begin his observations on the woman who sold the tickets, and also to ask if she was pretty. When he reached his destination, in the middle of the night, he asked his companion if that woman was pretty. The companion, being for once worried, tired, or forgetful, answered that he had not looked at her, and did not know anything about it. This was enough to cast the patient into such a condition of anxiety that he had to start back immediately for Paris to assure himself as to the truth in the matter!

If I have been able to give a general idea of this curious mental disorder, it will be agreed that, amid all its diversities, it is essentially characterized by a kind of cerebral pruriency which nothing can satisfy, and that the repetition of the same acts, the same questions, and the same thoughts, appertains to an organic phenomenon which brings up unceasingly the same impressions. In a similiar way we contend with ourselves laboriously, while dreaming, in a situation we can not bring ourselves out of, because the incessant repetition of the same physical impressions reproduces the same series of ideas. We are not finally delivered from this obsession till we wake.

The doubting folly is hard to cure, but considerable periods of remission sometimes occur, during which the patient seems to be restored to his normal condition. Unfortunately, the amelioration is seldom permanent. The brain falls back into its old habits, and the delirium begins over again. Patients who are attacked by it at the period of puberty have a better chance of recovering than others, for the progressive evolution of the organism may bring them relief from this psychologic condition. On the other side, the malady hardly ever ends in insanity. The subjects, when they have reached the last stage of their malady, remain fixed in their delirium. Incompetent for all work, sad and morose, they retire from society and live in voluntary sequestration. The prognostic is therefore extremely grave, for in the great majority of cases the future is definitely lost, whatever remissions of longer or shorter duration may give birth to slightly founded hopes.

The causes of the doubting folly are quite numerous. Heredity must be placed in the first rank; then comes puberty, which impresses a peculiar stamp on the psychoses that are brought under its influence. Sexual and intellectual excesses may also be included among the causes. Women are supposed to be more subject to the aberration than men. The disease is sometimes developed during convalescence from grave sickness. A certain part in producing it is attributed to moral per-

turbations, to lively emotions, and sudden frights. Frequently, as in the case of the patient who has been referred to so often, the origin of the disease entirely escapes us.

While suitable medical remedies are no doubt proper in their place, the principal part in the treatment should be given to moral remedies. It is, of course, useless to reason with the patient, or to try to show him how baseless his delusion is; but his attention should be engaged and his mind diverted from the set ideas that tyrannize over it, and a wisely arranged intellectual gymnastics should be prescribed. Physical exercise may also be made of service in turning to the profit of the body a little of the exaggerated activity that torments the mind. A final remedy is sequestration in a sanitary institute. It need not be applied to all patients, but may evidently be of use in cases where the surroundings, the habits of life, and the occupations to which the subject has been devoted, seem to have participated to any extent in the explosion of the psychical troubles.

THE PROGRESS OF AMERICAN MINERALOGY.*

By Professor GEORGE J. BRUSH,

RETIRING PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Mr. President, and Fellow-Members of the American Association for the Advancement of Science: The change in the Constitution effected at our last meeting, extending the scope of the Association and dividing it into nine sections, each with a vice-president, whose duty it is to deliver an address to the section over which he presides, has relieved the retiring President from attempting a general review of the progress of science during the past year.

I turn, therefore, to a more special subject, and invite your attention this evening to a sketch of the progress of American mineralogy, since the commencement of this century, with particular reference to the labors of some of the early workers in the science on this continent.

During the last quarter of the eighteenth century, while great activity existed and rapid advance was made in the study of chemistry and mineralogy in Europe, almost nothing was accomplished in this new country. It is true that students in other departments of science, especially members of the medical profession, in the cities of Philadelphia, New York, and Boston, attempted to arouse an interest in mineralogy, believing that the diffusion of a knowledge of this science would be of the utmost importance in the material development of the

* An address delivered before the American Association for the Advancement of Science, at Montreal, August 23, 1882.

country. There were, however, no text-books to aid the inquirer. There were no collections of minerals to stimulate the student. In the absence of these it was almost impossible that an interest in this science should be fostered, or that a spirit of investigation should be awakened.

As the first distinct beginning of the science, I may mention an association formed in 1798 in the city of New York, which assumed, as they expressed it, "the name and style of the American Mineralogical Society." It announced as its object "The Investigation of the Mineral and Fossil Bodies which compose the Fabric of the Globe, and more especially for the Natural and Chemical History of the Minerals and Fossils of the United States." The distinguished Dr. Samuel Latham Mitchill, who seems to have been a man of universal genius, was at once its first president, its librarian, and its cabinet-keeper. The committee of the society issued a circular in which, while expressing themselves "desirous of obtaining and diffusing by every means in their power a correct and extensive knowledge of the mineral treasures of their country, they earnestly solicited their fellow-citizens to communicate to them on all mineralogical subjects, but especially on the following," viz.:

1. Concerning the stones suitable to be manufactured into *gun-flints:* where are they found? and in what quantity? 2. Concerning *native brimstone or sulphur* or the waters or minerals whence it may be extracted? 3. Concerning *saltpeter:* where (if at all) found native? or the soils which produce it in the United States? 4. Concerning mines and ores of *lead:* in what places? the situation? how wide the vein? in what kind of rock it is bedded?

This warlike demand seems to call more for the discovery of the materials for national defense than for the advancement of science, and, besides being a commentary on the spirit of the times, gives a rather humorous impression of their strangely inadequate conception of the science of mineralogy and its possible bearings on practical life. But in justice to them I should add that it is further announced that "specimens of ores, metals, coals, spars, gypsums, crystals, petrifactions, stones, earths, slates, clays, chalks, limestones, marbles, and every fossil substance that may be discovered or fall in the way of a traveler, which can throw light on the mineralogical history of America, will be examined and analyzed without cost, sufficient pieces, with the owner's leave, being reserved for placing in the society's collection." I have quoted the circular almost *verbatim* to give you some idea of the genuine though crude longings for knowledge felt by our early mineralogists, and also of the generous spirit in which they worked.

A still more forcible picture of the ignorance of the time is given by the elder Professor Silliman in 1818. "Notwithstanding the laudable efforts of a few gentlemen," he says, "to excite some taste for

mineralogy, so little had been effected in forming collections, in kindling curiosity and diffusing information, that only fifteen years since (1803) it was a matter of extreme difficulty to obtain *among ourselves* even the *names* of the most common stones and minerals; and one might inquire earnestly and long before he could find any one to identify even *quartz, feldspar*, or *hornblende* among the simple minerals, or *granite, porphyry*, or *trap* among the rocks. We speak from experience, and well remember with what impatient, but almost despairing curiosity we eyed the bleak, naked ridges which impended over the valleys and plains that were the scenes of our youthful excursions. In vain did we doubt that the glittering spangles of mica and the still more alluring brilliancy of pyrites gave assurance of the existence of the precious metals in those substances, or that the cutting of glass by the garnet and by quartz proved that these minerals were the diamond; but, if they were not precious metals, and if they were not diamonds, we in vain inquired of our companions, and even of our teachers, what they were."

Such, then, was the state of knowledge in mineralogy here at the commencement of the century. A few American minerals, collected by travelers from time to time, had before this been taken to Europe for identification, but among these were discovered only two minerals new to science. The Moravian missionaries found at St. Paul, in Labrador, the beautiful species of feldspar called by Werner *labradorstein*, which in more modern times we know under the name of *labradorite.* Klaproth, the most eminent analytical chemist of his time, discovered that the so-called fibrous barytes from Pennsylvania was the sulphate of the then newly discovered earth strontia. He thus, for the first time, identified the mineral species *celestite* which was subsequently found in various localities in Europe.

Although little had been accomplished in America previous to 1800, the first quarter of the new century was destined to show great development here in the study of mineralogy. During the early years of this quarter several collections of European minerals were brought to this country by American gentlemen who had availed themselves during a residence in Europe of the best opportunities for acquiring a knowledge of the science from the great masters of the subject in Germany and France. About this time also several colleges in the country had instituted chairs of chemistry and mineralogy, and a commencement was thus made in teaching these sciences in the higher schools. As the result of these influences the number of persons interested in mineralogy was largely increased, and an active search for minerals was initiated throughout all of the older United States and to a considerable extent also in Canada.

So energetically were these explorations followed up that in 1825 a "Catalogue of American Minerals" was published by Dr. Samuel Robinson, with their localities arranged geographically, and giving

only such as were known to exist in the United States and the British Provinces. It formed an octavo volume of over three hundred pages. That much credit was due to *many* workers during this period, both in the field and in the laboratory, there can be no question, but among them all I find four men standing forth so prominently as leaders that I have thought it would be well for us to recall briefly something of the character of these men and their labors for the advancement of mineralogy in this country.

First among these I will mention Dr. Archibald Bruce. He was the son of Dr. William Bruce, a surgeon in the British army, and was born in New York in 1777. He was graduated at Columbia College; subsequently studied medicine, and in 1798 went to Edinburgh, where, in 1800, he obtained his doctor's degree from that university. He was early interested in natural science, and while still in college found, his biographer says, "the collection and examination of minerals—a pursuit not then at all attended to in this country—was his particular relief from other studies; for even during his recreation he was ever on the lookout for something new or instructing in mineralogy."

When he went to Europe he took with him a large number of American minerals, and, through exchanges with institutions and prominent mineralogists abroad, he established friendly relations with those most interested in his favorite science. After the completion of his medical studies, he traveled for two years on the Continent of Europe, making the acquaintance of the Abbé Haüy, and other eminent mineralogists, and collecting an extensive cabinet of valuable minerals, which, on his return to this country in 1803, he brought with him to New York. This collection, with another brought to New York about the same time by Mr. B. D. Perkins—both being made fully accessible to all interested in seeing them—contributed, it was said, more than any agencies had ever done before to excite in the public an active interest in the science of mineralogy. Besides this, Dr. Bruce entered into extensive correspondence with others interested in the subject, was active in visiting and discovering new mineral localities, and in advising, encouraging, and inspiring young mineralogists. Finally, after well considering the matter, he established the first purely scientific periodical ever published in America. This was called the "American Mineralogical Journal," and the first number of it was published in 1810. It contained original contributions, chiefly on mineralogy, from a number of investigators. "It was received," says the elder Silliman, "in this country and in Europe in a flattering manner; it excited at *home* great zeal and effort in support of the sciences which it fostered, and *abroad* it was hailed as the harbinger of our future exertions." But alas! it was in advance of the age, and, after struggling for several years, was given up on the publication of the fourth number. Possibly it would have continued longer had it not been for the failing health of its founder.

This journal contained several important papers by Dr. Bruce; among them, the investigation and description of two new mineral species, the *native magnesia* of Hoboken and the *red zinc oxide* of Sussex County, New Jersey. These are the first American species described by an American mineralogist. So thoroughly was the work done by Bruce, that these species remain to-day essentially as he described them, and his papers may well be studied by mineralogists now as models of accuracy and clearness of statement. . . .

I have mentioned that the importation and exhibition of collections of minerals from Europe had contributed much to excite an interest in the study of mineralogy. It was necessary to have known minerals for study and comparison in order properly to determine those obtained by exploration here. In 1805 Colonel George Gibbs, of Rhode Island, for many years a resident in Europe, returned from his travels with a collection of minerals, the most extensive and valuable ever brought to America. Colonel Gibbs was a zealous cultivator of mineralogy, and, fortunately for science, a young man of wealth. He used his money freely for the purchase of whole cabinets, as well as in personal explorations in search for minerals.

The larger part of his collection was made by the purchase of two famous European cabinets: one from the heirs of Gigot d'Orcy, a noted French collector, and said to have been the result of forty years' labor; the other from Count Gregoire de Razamowsky, a Russian nobleman, long resident in Switzerland. D'Orcy's cabinet numbered over four thousand specimens, chiefly from France, Germany, Italy, and Great Britain; Razamowsky's contained about six thousand specimens from the Russian Empire, and the remainder principally from Germany and Switzerland; in all, with the other collections made by Colonel Gibbs, it is said that more than twenty thousand specimens were brought by him to this country.

In 1807 a portion of this collection was opened in Newport, and many interested in mineralogy made pilgrimages there, to view the treasures it contained. Among others was Professor Silliman, who states, in his diary, that he spent many weeks in studying the minerals with Colonel Gibbs, finding in the latter "a scientific friend and a professional instructor and guide." That Colonel Gibbs reciprocated Professor Silliman's feelings of friendship there can be no doubt, for, after various offers to deposit his collection for exhibition in Boston, New York, and elsewhere, to the great surprise of Professor Silliman, he proposed to open the cabinet at Yale College, provided rooms should be fitted up for its reception.

The proposition was promptly responded to by the authorities of the college, and in 1810, 1811, and 1812, under the personal supervision of Colonel Gibbs, it was opened and arranged, and generously placed at the disposition of the institution and the public. The opening of this collection in New Haven formed an important epoch in the history

of the college, and gave a powerful impetus to science throughout the country. It was not only studied by the pupils of the college, but it was visited by travelers from all parts of the United States.

In 1825 the collection had for fifteen years been exhibited without any advantage to the owner, other than the satisfaction of observing the great amount of good which was effected by the knowledge it disseminated and the enthusiasm with which it inspired students. Colonel Gibbs then offered the whole for sale, giving the college the preference as purchaser. Fortunately, and mainly through the influence of Professor Silliman, the institution succeeded in raising the funds ($20,000) necessary for its purchase, and the ownership of this collection has exercised a most important influence in the development of natural science at New Haven.

Colonel Gibbs, however, did not confine himself to the collection of minerals in Europe. On his return to this country he made extensive journeys and opened up new mineral localities, giving his time and specimens freely to aid others who were interested in this special study. At Yale, as an incentive to students, he for many years offered prizes for superiority of attainments in mineralogical knowledge and for services rendered to the science by useful discoveries and observations.

He published valuable papers both in the "American Mineralogical Journal" and the "American Journal of Science," and did much by his counsel and co-operation to support these publications. Indeed, it was from Colonel Gibbs that Professor Silliman first received the suggestion that he should institute a new journal of science, in order that the advantages already gained by the short-lived "Mineralogical Journal" might be secured, and further progress for science might be made. . . .

Much as had been accomplished by the free exhibition of cabinets and the explorations and investigations of enthusiastic workers in mineralogy during the years from 1805 to 1815, a great drawback was now felt to the progress of the science from the want of text-books. Most of the literature of the subject was in German and French, but the works of the French and German authors had not then been translated, and consequently were accessible only to the few who were acquainted with these languages.

In English there were not many treatises on the subject. That by Richard Kirwan, the eminent Irish mineralogist of the last century, was a renowned work in its day, but, as the last edition of it had been published in 1794, it was already too old to be of much service to the student. Jameson's treatise was somewhat more recent (1804), but its great fullness and exclusive devotion to the Wernerian system made it an undesirable book for beginners, aside from the fact that its price was such that few students in those days could afford to buy it. So much progress had been made at home and abroad, that a work

was needed here which should include the modern discoveries, and one also which should gather up the scattered facts already published in regard to American minerals.

Fortunately for the further progress of science in this country, this was done by Professor Parker Cleaveland. His work was published in 1816, and was entitled "An Elementary Treatise on Mineralogy and Geology."

Professor Cleaveland was Professor of Mathematics and Natural Philosophy in Bowdoin College, and, like many other professors of science in the early history of American colleges, was charged by the trustees to lecture also on mineralogy and chemistry. He was an enthusiastic student of mineralogy, was well acquainted with the literature of the science in various languages, had been a successful teacher of the subject for many years, and withal was both an explorer and investigator, and held intimate relations with the leading mineralogists of the day. The work was modeled on the general plan of Brongniart, combining the excellences of both the French and German schools, and gave in detail almost everything then known in regard to American minerals. It supplied the pressing need for a thorough, systematic, and *American* treatise on mineralogy, well suited to all classes of students, and it was written in such a masterly style that it won for its author the highest praise from the leading mineralogists of the world. "It brought," says Professor Silliman, "within the reach of the American student the excellences of Kirwan, Jameson, Haüy, Brochant, Brongniart, and Werner, and we are not ashamed," he says, "to have this work compared with those of these celebrated authors." His biographer states that "he received letters of respect and congratulation from Sir David Brewster, Sir Humphry Davy, and Dr. McCulloch, in England, from Berzelius, in Stockholm, Germar of Halle, from Brongniart, Baron Cuvier, and the Abbé Haüy, in Paris."

The work at once took rank as one of the leading authorities on the science, and was introduced as a class-book in the principal schools and colleges in America. The first edition was soon exhausted, and a new and revised edition, with more than a hundred pages of new matter, was published in 1822. The demand was so great that this likewise was soon out of print, and a third edition was called for by the public; but Professor Cleaveland had about this time become so engrossed in the administration of the affairs of the new Medical School at Brunswick that he was unable to respond to the call, having turned his thoughts and efforts in new directions.

Unfortunately for the science of mineralogy, in which he had obtained such eminence as an author and teacher, he no longer contributed actively to its progress, although he continued his work as lecturer on the science so long as he lived.

The last to be mentioned of these early leaders is Professor Benjaman Silliman. His name is so intimately associated with the progress

of science on this continent during the first half of the present century that his life-work is more or less familiar to all. But the important service he rendered in the early history of mineralogy deserves especial recognition here, not only for the work he himself did in the laboratory and the field, but because his enthusiasm and zeal were a constant inspiration to others.

Commencing with the historic "candle-box" of unlabeled stones which he took to Dr. Adam Seybert, of Philadelphia, to be named, he began with enthusiasm the acquisition of knowledge and the gathering of material to illustrate the mineral kingdom. During a residence in England and Scotland, in 1805–'6, he had opportunities to add to his information, and collect many specimens, chiefly from the mines of Derbyshire and Cornwall. On his return to America he at once applied the knowledge he had acquired in making an exploration of the mineral structure of the environs of New Haven, and read a paper on this subject to the Connecticut Academy of Arts and Sciences in September, 1806.

In the following year he induced the corporation of the college to purchase the mineral collection of Mr. B. D. Perkins, of New York (already referred to), for one thousand dollars, thus placing the institution in possession of means for illustrating the science of mineralogy far in advance of anything it had before enjoyed.

The occurrence of the fall of the Weston meteorite in December, 1807, offered an opportunity for Professor Silliman to undertake, in connection with his colleague, Professor Kingsley, an investigation into the circumstances of the phenomenon, and the character of the stones which fell at that time. The results of this investigation were presented to the American Philosophical Society, and published in the "American Philosophical Transactions," in 1809. The diligence employed in obtaining all the facts possible from eye-witnesses of the occurrence, and the care and skill shown in the chemical and mineralogical examination of the meteorite, made this paper one of the most remarkable memoirs of the time, and attracted the attention of philosophers throughout the world.

As already stated, it was the personal enthusiasm and magnetic influence of Professor Silliman which led Colonel Gibbs to deposit his great cabinet of minerals in New Haven, under the care of his friend. It was due to the same qualities in Professor Silliman that the college secured the permanent possession of this invaluable collection, which probably has done more to create an interest in and disseminate a knowledge of mineralogy in this country than any other single agency.

The establishment of the "American Journal of Science" in 1818, now everywhere recognized as of inestimable value to all departments of science, was peculiarly helpful to mineralogy, and the early volumes are rich in articles on this subject. Professor Silliman's original contributions to science were more in chemistry and geology, but he also

is the author of several important papers on mineralogy, and was the discoverer of the occurrence of native tungstic acid as a mineral species. For more than fifty years he continued as teacher in Yale College, and when he resigned his professorship, in 1853, he had the satisfaction to have as his successor in the department of mineralogy and geology Professor James D. Dana, who was already among the foremost mineralogists of the day, and whose published works, before and since his accession to this professorship, have done so much for the advancement of mineralogy. . . .

It will be inferred from what has been said of these pioneers that the developments and discoveries of minerals, during the first twenty-five years of the century, were due entirely to individual enthusiasm and private enterprise. Up to this time no aid had been received from either State or national governments, and in looking over the work accomplished during this period we are filled with wonder and admiration at the energy and rare devotion to science exhibited. The larger portion of the continent was an unbroken wilderness, and the facilities of communication even in the settled parts of the country were of the most primitive character. Yet at the present day, with our means of rapid transportation, many naturalists would hesitate to undertake the long journeys then made for purely scientific purposes.

Geologists as well as mineralogists will recall how much science is indebted to such men as William Maclure, James Pierce, Thomas Nuttall (the botanist), and others who made extensive trips through the whole territory east and in some instances to the west of the Mississippi River. Maclure not only devoted his time and money to making and publishing a geological survey of the United States and Canada, the first report of which was made in 1809, but to him the Academy of Natural Sciences, in Philadelphia, owes its first endowment.

I shall be pardoned, I trust, if I mention still another signal instance of private liberality in this connection. General Stephen Van Rensselaer, of New York, a generous patron of science, defrayed all the expenses of a geological survey of the country adjacent to the Erie Canal, including the making of a geological section from Lake Erie to the eastern coast of Massachusetts. This survey was under the charge of Professor Amos Eaton, with a competent corps of assistants, and was continued for four years, from 1820 to 1824, at a cost of many thousands of dollars. General Van Rensselaer was also the founder of the first school of technical science in this country—the Rensselaer Polytechnic Institute, at Troy, which was placed under the charge of Professor Eaton. It may be interesting here, in these days of summer schools, to recall, although parenthetically, that what was probably the first Summer School of Science in the United States was established more than fifty years ago in connection with this institution. The school consisted of a flotilla of towed canal-boats, and the route was from Troy to Lake Erie. It took two months for the trip, and visited

all important points on the way. Instruction by lectures and examinations was given in mineralogy, geology, botany, zoölogy, chemistry, experimental philosophy, and practical mathematics, particularly land-surveying, harbor-surveying, and engineering. One of the largest boats in the flotilla was fitted up as a laboratory, with cabinets in mineralogy and geology, and also scientific books for reference. Students were taught the method of procuring specimens, and were required to make collections of whatever was interesting on the route.

The public mind was finally awakened to the importance of the work which these explorers and investigators had carried on single-handed. Government now came to the aid of science. In 1824 one State Legislature, that of North Carolina, authorized a geological survey to be made. This example was followed in 1830 by Massachusetts, and soon after by New York, Pennsylvania, Virginia, and other States, and also by the national Government, until, as is now well known, the whole territory of the United States and Canada either has been or is in the process of being surveyed. Several of the State surveys published independent volumes on the mineralogy of their respective States, and these surveys have been a powerful auxiliary in extending our knowledge of the occurrence of minerals on this continent. The opening of mines and quarries throughout the country has also furnished abundant material for study. The large number of original contributions which have been published in the volumes of State surveys, the treatises by American authors, and the still larger number of memoirs and papers communicated to our academies of science and scientific journals, can not be even enumerated in this place; neither is it my purpose to attempt to give here a list of the names of those who have been actively engaged in making researches on American minerals. Still less can I attempt to give an account of the work that has been and is being done by living mineralogists. The sketch which I have presented of the four typical workers has in a measure shown the character of our early mineralogists, the earnest spirit in which they labored, and what they accomplished in the first quarter of the century. The point to which the science has reached in the last quarter of the century can not be unfamiliar to you all.

In the time that remains I desire to call your attention to some of the developments made in the field in which our mineralogists have worked. It was thought by many scientists in the first half of this century that our rocks seemed likely to afford less variety of mineral contents than the rocks of Europe. Further study, however, and more careful and extended observations, encourage us to believe that our mineral riches, even in variety of species, will compare favorably with those of other continents. Already fully one half of the known mineral species have been found here. The present number of known minerals is variously estimated to be from seven hundred to one thousand. There have been described, as occurring here, nearly three hun-

dred supposed new American minerals. Of these, perhaps one quarter are new to science, and the remainder have either been proved to be identical with species already described, or their characters are so imperfectly given that further investigation is needed to ascertain what they are. Among these new minerals are some of great interest to science. . . .

In comparing the minerals found in America with those of Europe, although interesting minor variations are observed, it can hardly be expected that very marked differences should exist. This is, of course, due to the fact that, in the inorganic kingdom, Nature has everywhere to do with the same elements, under essentially like conditions. A large number of remarkable analogies between the minerals of the two continents will occur to any one familiar with the subject, as, for example, the character of the occurrence of individual minerals in the rocks of the Northeastern United States and Canada as compared with those of Norway and Sweden, and numberless instances of like association of minerals in various parts of Europe find their counterparts here.

A marked feature of American minerals is the grand scale upon which crystallization has taken place, individual crystals of large size being very common. The granite veins of New England afford striking examples of this kind. We have common mica, in sheets a yard across; feldspar has been observed where a single cleavage-plane measured ten feet; gigantic hexagonal prisms of beryl, four feet long and more than two feet in diameter, and weighing over two tons, have been described; spodumene crystals, six to seven feet in length and a foot or more across, and masses of rock-crystal of immense size, have been found. Canada and New York have given crystals of apatite, phlogopite, and sphene, which for these species are of marvelous grandeur in dimensions. Many other American localities might be mentioned where giant crystals occur. While it is true that these are extraordinary instances, it is also true, as a general fact common to a very large proportion of the minerals found in this country, that the species occur in much larger crystals than those obtained from European localities.

Another point worthy of note is the occurrence in comparatively large quantities, and over wide areas, of some of the rarer elements as constituents of the minerals found. In illustration of this we have, among the rare earths, *glucina* combined with silica and alumina in the mineral *beryl*, occurring in large quantity and perhaps in a hundred or more places; *zirconia*, in the mineral *zircon*, is also very widespread in its range of occurrence as an original constituent of the older rocks, as well as a vein-mineral; localities are known which have furnished this rare species by the hundred-weight. The *cerium* earths are found largely in the mineral *allanite*, which occurs in so many places that it may be said to be a common mineral in the United States. These earths are also found in the rare phosphate *monazite*, a

mineral that in America has a wide range of localities, and recently this species has been found in crystals of two, three, and, in one instance, of eight pounds in weight. Again, three new earth-metals —*mosandrum*, *phillipium*, and *decipium*—have been described as occurring with the cerium earths and yttria in the North Carolina *samarskite*. The rare alkali metal *lithium*, sometimes associated with the still rarer metals *rubidium* and *cæsium*, is found not only of wide-spread occurrence in our lithia micas, but the mineral *spodumene*, containing from five to eight per cent of lithia, occurs by the ton in at least one locality, and must be looked upon as one of the common American minerals, being found in the granite veins in Maine, New Hampshire, Massachusetts, and Connecticut, and as far south as North Carolina and Georgia. Lithia also is one of the constituents of the phosphate *triphilite*, and there are several localities known where this mineral occurs abundantly. Again, we have the frequent occurrence of some of the rare metals which form metallic acids: *Columbium*, the first metal, new to science, discovered in America, associated with its twin metal *tantalum*, is found in columbite in our granite veins from Maine to Georgia, a range of more than a thousand miles, in a score or more of places, and sometimes is obtained by the hundred-weight at a single locality. The American variety of *samarskite*, another rare columbate, has also been found in masses of fifty pounds or more in weight, and these acids occur in still other American species. *Molybdenum*, both as sulphide and in the oxidized form as native molybdic acid and molybdate of lead, is found in many localities, and occasionally in large quantity. Quite recently *vanadium* compounds have been discovered in several places, and *tungstates* have also been observed over a wide range of country. *Titanium* has been found in enormous quantities in extensive deposits of titanic iron as well as in the form of rutile and in sphene. The rare metal *tellurium* occurs native in Colorado in one locality, where single masses of twenty-five pounds in weight have been taken out, and several new tellurium compounds have been found in our Western mines.

It is, perhaps, unnecessary to enumerate more fully the many occurrences of other rare elements in American minerals. Enough has already been said to show that important developments have been made in the discovery and investigation of the minerals found in our American rocks during the past eighty years. Nevertheless, it is but a commencement in the work. Only a very small portion of our territory has been explored with any thoroughness, and none of it exhaustively. The enormous production of the precious metals and the extensive deposits of ores of the more common metals which have been opened up during the past twenty or thirty years have placed us in the front rank as metal-producers, but we are still far behind Europe in the variety of minerals obtained from our mines. This may be due, in some instances, to the character of the veins or ore-deposits, there

being, as in many of our gold and silver mines, remarkably few associated minerals. In other cases, however, it is doubtless due to the fact that very few persons connected with our mines have even an elementary knowledge of the rudiments of mineralogy, while in continental Europe almost every mining officer is familiar with all the ordinary minerals. Thanks to the training of our schools of science, an improvement in this respect is already noticeable, as is shown in the discoveries made in the mines of our Western States and Territories during the past few years.

While the service done for mineralogy by our geological surveys is gratefully acknowledged, we feel that we have a right to demand much more from them in the future. Mineralogy has been too largely looked upon as a guide to the discovery of useful ores and minerals, and not as a matter for scientific study ; fortunately, during the past decade the discoveries in optical mineralogy and their importance in the determination of the constituent minerals of the crystalline rocks have led many geologists to again recognize the desirability of a knowledge of our science. Much will be accomplished if those in charge of geological surveys will direct competent persons to make observations, not only on the main mineral constituents of rocks but also in the manner of occurrence of individual minerals. The careful inspection of quarries and mines is greatly to be desired. These are rich sources for minerals, but, unless constant watchfulness is exercised, valuable material for science is in danger of being buried out of sight.

It is too true that many of the most interesting discoveries already recorded seem to have been due more to the result of fortunate accident than of systematic and intelligent exploration. If our trained mineralogists, instead of devoting most of their attention to the examination of specimens in cabinets collected by others, would give more time to personal observation in the field in the study of the order and manner of occurrence of mineral species in place, our knowledge would doubtless be greatly promoted. Again, if our wealthy amateurs could be induced to spend their money as freely in the exploration of promising American localities as in the importation of costly European specimens, we might hope for many important discoveries, and they could have the satisfaction not only of gaining novelties for their collections, but incidentally they would do much to foster science.

In order to keep pace with the progress of the science, we need many more workers who will devote themselves especially to mineralogical research, and we need more of the spirit of the early workers. It is my belief that the number of persons at present interested in the study here, either as amateurs or investigators, is relatively less than in 1825. The mineralogy of to-day is a very different subject from the mineralogy of the commencement of the period over which we have so hastily glanced. Then the study of minerals was confined almost exclusively to their external characters. Led by Werner and re-enforced by his

most gifted pupil Mohs, the majority of mineralogists claimed mineralogy to be a purely natural history science. They gave their attention, as has been well said, entirely to "*how the mineral looked*," and not at all to "*what it was*." On the other hand, the development of analytical chemistry by the labors of Klaproth and Berzelius led many to take up mineralogy from a purely chemical stand-point. These two schools working independently brought great confusion into the science. The discoveries of Haüy in crystallography, and especially his labors in establishing a mathematical foundation for the geometrical form of crystals, and the recognition that the constancy of form depended on the constancy of the "integrant molecule," were steps which paved the way for modern mineralogy. In this a union of all the physical, geometrical, and chemical properties is required in order to determine the true character of a mineral.

Further, we are called upon to investigate the history of its origin, its relation to associated species, the changes which it undergoes, and the causes and results of these changes. Here we have to do largely with both geology and chemistry. From this it becomes evident that a much broader foundation is now required for the mineralogist than in the early days of the century. The bearing of physics, geology, and chemistry, in the study of the mineral kingdom, must be thoroughly recognized and appreciated by every investigator who desires to contribute to further progress. No mineralogist can expect to have a profound knowledge in all these directions, but he must be at least capable of intelligently applying to his subject the results obtained by experts in these sciences. Mineralogy is deeply indebted to special investigators in all these departments. Without their co-operation it would have been impossible to discover the relations of form and other physical characters with that fundamental arrangement of molecules whose nature it is now admitted controls all the properties of a substance.

The study of natural crystals has yielded rich material for the physicist. In the department of optics it has given results from which many fundamental laws have been deduced; and natural crystals, too, have furnished, in many cases, the very apparatus which made investigations possible. Some chemists claim that mineralogy is not at all a science by itself, and constitutes only a small part of inorganic chemistry. It can be unquestionably conceded that a knowledge of chemistry is fundamental, and in consequence this claim has a certain plausibility. On the other hand, we contend that it was largely the labors of the mineralogists on the physical characters of minerals, and especially their demonstration of the relation of form to chemical composition, which finally awakened chemists to a more profound study of their own subject. The law of isomorphism was discovered by a chemist, whose training as an expert crystallographer in the examination of natural crystals made it possible for him to recognize the wonderful relation of form to composition. Dimorphism was first established

from observations made on minerals, and it is in the study of the mineral kingdom that the laws of isomorphism and dimorphism find abundant demonstration. From the further investigation of the chemical nature of minerals we may hope for new light on the molecular constitution of substances which as yet the chemist has been unable to reproduce. We have already indicated the interdependence of geology and mineralogy. May we not claim the same interdependence of mineralogy, physics, and chemistry, letting each go on in its own sphere, contributing to the general progress, sure that every new fact observed and every new law discovered will be for the common advancement of all?

INDUSTRIAL EDUCATION IN THE PUBLIC SCHOOLS.*

By Professor H. H. STRAIGHT.

THERE is a growing feeling among the students of industrial problems that our whole conception of education in general, and of industrial training in particular, needs revision and enlargement. This feeling is based upon such easily observed facts as the following:

1. Paupers are on the increase.

2. Our schools too often educate their pupils out of harmony with their environment, thus justifying the charge that education (falsely so called) unfits its possessors for useful industry.

3. The simpler and less important positions in the world's workshop are as a rule greatly overcrowded, while in the upper stories there is a vast amount of unoccupied space.

4. The work done in the lower stories is often exceedingly shabby.

5. Many who aspire to the upper stories fail to enter—or, if they apparently enter, soon end in failure.

6. The chosen few who truly enter, and build up magnificent industrial fabrics, with the splendid fortunes which such fabrics imply, fail to educate their children to carry on their good work, or to do work of similar value in some other department of useful industry.

7. A whole community of prosperous workmen may be well-nigh reduced to beggary by the incoming of some new invention, or by change in the fortunes or tastes of consumers.

8. When old industries are swept away, and new ones established on the wrecks, there is usually little power on the part of workmen to adapt themselves to the new conditions.

9. The relentless law of the survival of the shrewdest and most unscrupulous, instead of the Christian law of mutual consideration and

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co-operation, too generally prevails among individuals and all kinds of human organizations.

That all education should be industrial, and that everybody should be industrially educated, we believe to be a perfectly tenable proposition. For one to be industrially educated he must be in possession of the following elements:

1. An industrial disposition, which leads to a cheerful and even happy devotion to some chosen employment, as the avenue through which to make his contribution to the world's wealth.

2. Industrial knowledge—such general and special knowledge as will put him in possession of the best human experience in the direction of his chosen vocation.

3. Industrial power—such a development of physical, intellectual, and artistic power as will remove as far as possible the chances of failure, and, by giving a just consciousness of strength, will enable him to work always with the hope and expectation of success.

Will not all admit that it is at least desirable that such education should become universal?

In the brief time at our disposal, we can scarcely outline the place the public schools should occupy in the development of such a scheme and in the accomplishment of such results.

How can the industrial disposition be fostered? How can industrial knowledge be most economically and efficiently imparted? How can industrial power be developed? How can the different classes of the world's workers be brought into intelligent sympathy?

These are the great questions pressing for solution upon society in general, and upon the teacher in particular. Probably no friend of industrial education would claim that farmers, mechanics, or artisans of any kind, as such, should be fitted for their special work in the public schools, any more than that these schools should undertake the training of physicians, lawyers, painters, sculptors, statesmen. The public schools should rather form the road leading up to the base of the mountain of industry and art, thence branching to the various heights of the special industries, each special height having at its base a special school to fit its students for its climbing.

As all classes of our people are to be citizens of one common republic, popular education must extend sufficiently far to prepare for the one great common industry of citizenship. The power to read, write, and cipher, may be destructive or helpful to good citizenship, according as it is or is not guided by an intelligence suffused with conscientious regard for the rights of all men. This intelligence and regard can be developed only as the work of the schools is based upon a sound platform of principle. We believe this platform can be made so broad, so catholic—that its inherent naturalness and divinity shall be so readily apparent—that men and women, who desire to make united effort for the good of all, can easily stand upon it.

In the first place, the schools must recognize the true nature and place of the industrial instinct: that it is the creative instinct; one of the profoundest of the human soul, and one of the earliest to manifest itself. The plays in which the child finds his greatest delight are all embryo industries. My little two-year-old, who with his blocks and sticks builds a barn for his rubber camel, is as truly *creating* as the architect who, with greater skill and knowedge, constructs a palace. Why should not the *joy in producing*, which forms so large a part of the child's happiness, be carried forward into the industries of maturer years, deepened and ennobled by a knowledge of industrial relations, by experience of the value of industrial products, and, above all, by the consciousness of duty done in the contribution made to human comfort and well-being? Give this instinct a proper development, join with it the best human intelligence and the best human benevolence, and you have the ideal man—the man perfect as his "Father in heaven is perfect."

In the second place, the schools must make a wise selection from the accumulated knowledge of the world. They must impart that knowledge which will enable their students intelligently to decide which one of the special heights of industry or art each is best fitted to climb. They must give that knowledge which will reduce to a minimum the difficulties in the way of change from one industry to another, often rendered necessary by the accidents of time and fortune.

All classes of citizens must have the knowledge which will form a basis for intelligent sympathy and appreciation among different classes of workers, and necessary to their action at the ballot-box, in order that each may recognize all as honorable and necessary, essential parts of one grand industrial whole.

In the third place, the public schools must develop general industrial power:

(*a.*) Physical Power.—They must take the best physiological knowledge the age affords, and under its guidance develop a body capable of enduring all the strains and fatigues likely to be brought upon it by at least the ordinary exigencies of life.

(*b.*) Intellectual Power.—They must impart the knowledge which it is their duty to give—according to the laws of mental assimilation—as discovered and interpreted by the best students of mental growth, to the end that mental dyspepsia may be avoided, and that the best intellectual conditions may exist for the quick and accurate solution of at least the ordinary problems of life.

(*c.*) Artistic Power.—They must give such a development of the sense of the beautiful as will enable our people, not simply to enjoy the beautiful in the objects about them, but such as will give a *finesse* and finish to whatever work they undertake, whether it be the culture of corn, the making of a coat, the building of a house, or the

painting of a picture. Every workman should have, to the largest possible degree, the fine feeling of the artist, while every artist should be recognized as a working-man.

Over all this knowledge and these powers a conscience should preside that can say "*ought*" and "*ought not*" so loudly and distinctly that its commands can not go unheeded. This work is all to be done in the schools, through the ordinary subjects, properly related and taught.

I do not believe in multiplying subjects in our school curriculum. I believe most thoroughly in reducing them. Even among the old Greeks the time came when complaint was made that the children were pestered with a multitude of subjects, all thought necessary to a proper education, and accordingly all imperfectly acquired.

The territory and the time from which the Greek drew thought were but the merest fragment of that from which thought and material come pouring in upon the modern child. All ages and all climes are pouring their accumulated treasure and filth upon him. Selfishness and ignorance, backed by the hoarded wealth of generations, combine to force into his unwilling and aching mental stomach the products alike of malicious, shallow, and noble brains. The multiplication of subjects of study in the schools of ancient Greece was accompanied by a decline of mental vigor and spontaneity.

The only hope for our future lies in a wise choice of subjects for our schools—in a wise conservation and expenditure of the energies of our children. This multiplication of subjects, it seems to us, has grown out of a lack of proper appreciation of the essentials of the great departments of knowledge and their proper relations. What God has joined together, man, partly through ignorance and partly through desire of gain, has violently put asunder. Closely connected lines of study have been isolated. Great departments of thought have been cut up into petty fields, and then each little quarter-lot so covered by rubbish that teacher and pupil alike have been starved and enslaved when they ought to have been made vigorous and free through a knowledge of the truth. Industrial knowledge consists in acquaintance with industrial materials, processes, and relations.

Industrial materials are the various natural forces together with certain substances from the mineral, vegetable, and animal worlds. Industrial processes are those operations by which crude materials are converted into forms adapted to man's deeds. Industrial relations imply the mechanism of exchange, and all those considerations dealt with in political science. Let us consider briefly the possibilities of arithmetical teaching as a means of imparting solid industrial knowledge.

It was, doubtless, a great gain in teaching the elements of arithmetic when beans, corn, blocks, etc., were substituted for abstract statement. The principles stated and illustrated by Grübe, Horace

Grant, Colonel Parker, and others, that a great variety of objects should be used in teaching number; that change from one class of objects to another sustains interest; that seeing and handling many classes of objects train the observing powers to make distinctions and classify things, are sound from the stand-points both of principle and practice. The illustrations used are all good; we only suggest what seems to us an improvement and a great gain.

During the last few years we have been experimenting with classes of children in a variety of ways. One general conclusion from these experiments is that number-lessons can be utilized in teaching children to recognize a large variety of industrial materials, and this too with a positive gain in interest and impressiveness to the work in number itself. Children can be taught in this way to recognize the common and useful trees by their leaves, fruit, wood, etc.; the common rocks, minerals, ores; the more important kinds of goods used in clothing.

The fragments to be had at the shops of the tailor, milliner, dress-maker, upholsterer, of any town, would supply, without cost, all the materials desired in this direction. Samples of these materials could be artistically arranged in numerical designs upon thin board or paste-board and hung upon the walls for constant reference and review. It is no more difficult to say "two elm-leaves and three elm-leaves are five elm-leaves," "two sandstones and three sandstones are five sandstones," "two broadcloths and three broadcloths are five broad-cloths," etc., etc., than to say "two blocks and three blocks are five blocks."

A second conclusion from our experiments is, that measures, weights, and moneys can be taught more efficiently than now, along with the early teaching of the fundamental arithmetical processes.

Number, the idea of the single and plural, enters into all our knowledge both of the external and internal worlds, from the time consciousness begins to act, until death. Our very first act of knowing is the recognition of a difference between two sensations. Distinguishing external objects into the single and plural—the one and the many, the little and the big—is one of the earliest lines of investigation for the infant and child. The work of the first few months of school-life is to bring this unconscious mathematical experience out into consciousness, and to give the child the beginning of the exact and quantitative method of study.

A child can very early learn to count twelve with the objects before him; can then learn to find the number of objects in a given group by counting; then by a single glance, when the groups do not contain a larger number than he has learned to count.

He can just as early and in the same connection learn to recognize an inch, two inches, twelve inches; can draw given numbers of lines of these lengths; can cut them out of paper, pasteboard, and wood. Similar work can be done with the foot and yard. Corresponding

work can be done with the square and cubic inch and foot. The French measures can be used exclusively, or in connection with the English. Additions and subtractions can be performed with objects of these dimensions in the same manner as ordinarily with beans and blocks. The blocks may be made of wood of different kinds. Thus at the same time and with additional interest and effect there can be taught—1. The fundamental numerical operations; 2. The recognition of the useful woods; 3. The recognition of exact dimensions and proportions.

This last would lead at once into the investigation of the *dimensions* of the school-room, the objects in it, the parts of their own bodies, etc. The sense of dimension and proportion, generally so poorly cultivated, so important in numerous arts and industries, would thus receive an early and full development.

The constant drawing of these forms and dimensions, crudely at first, but more perfectly with practice, would lay an early and solid foundation for both mechanical and artistic drawing.

Why should not children early learn to mix paints and adorn their squares and cubes with the principal colors and their simpler hues and tints; then, with this as a foundation, go on to represent nature's simpler colors in the plant, animal, rock, and sky?

Thus not only would color-blindness be detected, but the color-sense would be thoroughly developed, and the foundation laid in the knowledge and power given for successful work in numerous lines of industry. We would, then, urge the practicability of using common industrial materials, objects of definite dimensions, weights, colors, imagined values, as the objects by means of which to develop primary conceptions of number and of numerical operations—thus adding to the interest, saving time, and imparting industrial knowledge.

For advanced work in the development and application of arithmetical principles, we would use such simple scientific apparatus as we have on exhibition, or those materials which would lead at once into some principle of political economy. It is our conviction that during the time ordinarily spent by a class upon ratio and proportion, there can be given a better knowledge of these subjects, as such, than is ordinarily given; and in the same time there can be taught, by actual experiment, the law of action of the lever, the laws of vibration of the pendulum, the number of vibrations in each note of the musical scale, and still other important scientific principles. The pupil certainly will have at the end a tolerably correct idea of the mission of ratio and proportion in the scientific and commercial worlds. He will not be likely to make those failures in the application of simple arithmetical principles to scientific and commercial problems with which (I know from experience) he is at present justly credited.

The result of such a method would be to show definitely the place of mathematical science in the progress of civilization. The whole

study would be dignified and glorified as is every kind of truth, when its true place and mission are discovered.

Do I hear you say, "This is all very fine in theory, but impossible in practice"? "We can not get the apparatus—we can not find the teachers"?

As for myself, I have no time for building castles in the air which can not be brought down to earth and built of solid material. Here are a few facts of positive knowledge: For a few dollars a working-room or corner can be fitted up where all necessary apparatus can be made. There is no school whose boys and girls will not become enthusiastic in this kind of work, provided they have a little direction and encouragement of the right sort. The necessary funds for a beginning may be furnished by an exhibition, or by subscription of parties to whom the subject has been properly presented. It is our very positive conviction that for a much smaller sum than most people imagine there can be fitted up a school workshop in which the following results can be accomplished:

1. There can be made all the apparatus necessary to give a most excellent course in the elements of physical science.

2. There can be made, wholly or in part, blocks, weights, etc., whose use we have described.

3. Old bottles, test-tubes, tumblers, etc., can be graduated for the practical teaching of the liquid measures—each pupil having his own set of measures.

4. Easels, rules, etc., can be made for use in drawing.

5. Cases, shelves, brackets, etc., can be made for collections and for beautifying the room.

6. Pictures can be framed.

7. There can be made most, if not all, of the needed gymnastic apparatus, i. e., clubs can be turned, etc.

In short, the pupils can do a very large part of the work of properly fitting up the school-room, and this work can be so planned as to teach in the doing of it all the fundamental processes concerned in the various industries that deal with wood and metal. All this could be fitted into other lines of industrial work (sewing, modeling), and thus might be worked out a consistent and comprehensive scheme of general industrial training. Where are the teachers to be had? Let those who are giving their best thought to the problems of education first determine the sort of work that can and ought to be done in the schools, then let them submit their plans to the people through press and platform, and then reform the normal schools to suit the desires and demands of the people thus instructed. Consider for a moment what can be got out of a single piece of apparatus such as this system of levers:

1. There are the industrial processes concerned in its manufacture, making a smooth surface, a straight edge, a good joint, dividing

the lever into equal parts, adjusting weights, little or more work with metal, according to taste and time—the wood may be finished in oil, varnish, or paint.

2. A good lesson in form can be given upon it.

3. It affords an excellent exercise in drawing.

4. There can be performed a series of simple experiments involving no mathematics. These may be made the basis of a series of simple language-lessons, the children observing the experiments and describing what is done and the results.

All this prepares the way for experiments involving arithmetical processes and leading to the law of the lever's action. I can imagine no better way of teaching ratio and proportion than through the results obtained from this series of experiment. The stimulus, interest, definiteness of thought coming from this method would more than compensate for the extra time.

5. The story of Archimedes and the discovery of the principle of the lever would interest a class of almost any age. Nothing could be better to cultivate language and develop the historical sense than the reproduction of such stories in oral and written speech.

This illustrates the uses to which I would put every piece of apparatus in our exhibit.

There is another very important item. The *forms* in which arithmetical quantities are actually put in commerce and science should be *forms* in which they come before the children in the schools. They should learn the ordinary business forms and operations, and should get a sense of the values of industrial products, in connection with their regular work in school.

These can be taught incidentally in connection with such language-lessons as I have indicated—punctuation, forms of address, and nearly all the mechanism of writing, as ordinarily treated in works upon elements of composition and rhetoric.

During the last year, in my own teaching, I have had the reproductions of lessons in physics, geology, and natural history, put in forms of letters, advertisements, etc. The novelty added to the interest, while the many changes in the form of reproduction changed the point of view, stimulated thought, and caused the work, as a whole, to make a deeper impression.

The special value to the pupils of our schools, of the work involved in such an industrial course as we have indicated, would be:

1. The cultivation of observation and judgment, the discipline of hand and eye, obtained in this way, would not be second to that obtained in any other way.

2. The course in mathematics, together with the course in language and geography, could be made the means of acquainting them with those natural products and forces which underlie all industries and all arts.

3. They would learn in a general but efficient manner the fundamental industrial processes which underlie the more special processes of the common arts.

4. This general but genuine knowledge of materials, forces, and processes, will enable each student to choose, with a fair degree of intelligence, the industry for which he or she is fitted by special taste and power.

5. Such a course would make far easier than now the change from one occupation to another, which must ever remain an incident of growing industries.

6. It would give to each person, as employer, some power to judge of the work of the employed.

7. It would furnish a basis, in intelligence, for general sympathy and appreciation among different classes of workers.

8. The last and greatest good would be the cultivation of the industrial disposition, and the killing out of the absurd idea that our schools are free.

The schools simply represent society organized for the education of its children. Every stroke of work done in these schools has to be paid for, and at the proper time children should understand this fact, and should manifest their gratitude by doing all in their power for the betterment of the schools and the proper equipment of the rooms. This, I conceive, would form a most fitting introduction to the great industrial world, and would go far toward building up that spirit of industry and mutual helpfulness which should form the essential characteristic of the American citizen.

PHYSIOGNOMIC CURIOSITIES.

By FELIX L. OSWALD, M. D.

If the proper study of mankind is man, it is a remarkable circumstance that the most important departments of that study are still alloyed with such an excessive percentage of spurious elements, and that their exponents persist in identifying their interests with the defense of those apocryphal parts of their doctrine. Hygiene, in the legitimate sense of the word, is simply the art of avoiding sins against the health laws of Nature, but the proposition to omit therapeutics (poison-mongery, as Dio Lewis used to call it) from the curriculum of a medical college would provoke a worse storm of protest than the first attempt to divorce astronomy from astrology. In points of ethics conservatism is a more than professional duty, yet the Rev. Mr. Freekirk, as well as Bishop Highchurch, and Rabbi Tabernacle, is tolerance in person till you question one of his mythological tenets. Phrenol-

ogy, or the art of deducing mental characteristics from physical indications, would have been recognized as a true science if its apologists had not wasted their efforts in the propaganda of their craniological crotchets.

Pliny, and his countryman Campanella, already observed that the art of interpreting the features of the human face is a universal one, practiced by unformulated but well-understood rules, ever since man tried to fathom the soul of his fellow-man. "Every one," says Addison, "is in some degree master of that art which is generally known by the name of *Physiognomy*, and naturally forms to himself the character or fortune of a stranger from the features of his face. We are no sooner presented to any one we never saw before, but we are immediately struck with the idea of a proud, a reserved, an affable, or a good-natured man. For my own part, I am so apt to frame a notion of every man's humor or circumstances by his looks, that I have sometimes employed myself from Charing Cross to the Royal Exchange in drawing the characters of those who have passed by me. I can not recollect the author of a famous saying to a stranger who stood silent in his company, 'Speak, that I may see thee.' But with all submission I think we may be better known by our looks than by our words, and that a man's speech is much more easily disguised than his countenance." Even in their present crude and incoherent condition the rules of this art of symbol-reading have a far greater interest than those of our dogmatic skull-systems, which, besides minor confirmations, lack the important one of the *vox populi*. There is a deep meaning in the humorous remark of Professor Vogt, that, "if the tenets of Spurzheim were founded on fact, instinct would have taught us long ago to finger the occiput of a suspicious stranger instead of scrutinizing his face"; and the study of a phrenological bust somehow obtrudes the idea that a good deal of this cranial topography was suggested by *verbal analogies*, such as the location of our *higher* faculties in the attic of the skull while the *baser* propensities occupy the basement, or George Combe's conception that an elongated head must denote sagacity—*anglicè*, "long-headedness." Lavater's, Winckelmann's, Cuvier's, and Dr. Redfield's observations, on the other hand, are often indorsed by a multitude of analogous impressions which social studies or self-examination has left in our minds.

The comparison of modern physiognomic theories with the opinions of the ancients suggests many curious reflections, and may frequently serve to confirm one of those semi-conscious notions of our own which we derive from experience but neglect to "formulate." "Whitish hair, which at the same time is soft and thin," says Baron Cuvier, "denotes a feeble organization, a temper yielding and easily alarmed. It is commonly combined with an oval face and gently rounded head. Such heads are never found in the descriptions of malefactors. Black, frizzled hair the ancients considered as a sign of a

savage disposition." Who is not at once reminded of the timid, flaxen-haired inmates of our infirmaries and orphan asylums, and, on the other hand, of the "black, frizzled hair," so often combined with a bowie-knife and horse-pistol in the make-up of a prominent border-ruffian? And is it not confirmed by national as well as individual characteristics, that prominence of the canine teeth indicates pugnacity, or, as Dr. Carus terms it, "the love of overcoming"? The Bedouin Arabs and the Arizona Apaches have such teeth, and the physiognomies of Western hunters and teamsters and West Indian smugglers show that they are developed by adventurous pursuits.

If the experience of mankind is competent to interpret facial indications, some of the "propensities" and "perceptives" which Spurzheim lodges in the back rooms of his pan-sensorium must have a *penchant* for changing their quarters. "Firmness," for instance, which he locates in the posterior part of the upper head, undoubtedly manifests itself in the prominence of the *chin*. "Draw a face in profile," says Winckelmann, and observe how timidity or its opposite can be expressed by the shape of the lower jaw. Let the chin be receding, and your profile can be made to express pusillanimity and feebleness of character, even to the degree of imbecility. Then, without changing any upper line of the profile, combine it with a prominent chin, and it will exhibit firmness. Exaggerate the prominence, and you can intensify that expression to one of obstinacy and ferocity. That such contrasts are less striking in living faces is owing to the circumstance that we take in the expression of all features at a single glance, without analyzing the complex effect."

Have we not here a positive criterion, a rule without an exception? Does it not occur to us, on after-thought, that *all* warlike, aggressive nations have such projecting chins, while the weak or degenerate ones are more or less chin-less? In their classification of the North American aborigines the Spaniards distinguish between *Indios mansos* and *Indios bravos* (tame and savage Indians). The former comprise the different agricultural tribes of Central and South America, ignorant but harmless creatures, who subsist on a vegetable diet; the latter the carnivorous savages of the North, who divided their time between hunting and warfare. In their physical characteristics these various tribes of the American autochthones could hardly be distinguished, if it were not for a slight variation in the color of their skins and a very marked difference in the shape of their *chins*. Our redskins *have* chins, though they can not emulate those of the Indo-Germanic race; the Indians of Mexico and South America have none. In the profile of a vegetarian Indio from the neighborhood of Vera Cruz, the lower jaw recedes in a sharp line from the mouth to the throat, so that his nose, though not excessive in size, becomes ridiculously prominent. Obstinacy with a projecting chin and shrinking timidity with a receding one are here strongly contrasted, and the study of individual faces proves Winckel-

mann's rule to be almost, if not altogether, infallible. Can Professor Fowler point out a corresponding difference in the shape of the posterior skull? "Amativeness," too, may or may not affect the bones above the nape, but Theophrastus, Galen, Della Porta, Lavater, Dr. Redfield, and all portrait-painters, agree that it *is* disclosed by the *eyelids*, especially the lower ones.

Lavater and other critical students of the human face have shown the fallacy of some popular notions—for instance, the connection of a high forehead with superior intelligence—but also that generally received opinions differ less in different nations and ages than should be supposed; and it is surprising of what minute symptoms even the ancient nations have taken cognizance.

There is, indeed, hardly a facial muscle that has not been suspected of betraying mental peculiarities. "A forehead loaded with wrinkles" Aristotle supposes to indicate a gloomy, morose, and overbearing disposition, and furthermore thinks that, if these wrinkles are massed over the eye, it denotes cruelty. According to Galen, a depression in the center of the forehead announces a melancholy temper or a recollection of an awful crime, though he admits that physical excesses may produce the same effect.

"Vertical incisions in the *bone* of the forehead," says Lavater, "belong exclusively to persons of uncommon capacity and to independent thinkers." Perpendicular *wrinkles* he holds to be the emblems of wrath, because such furrows are formed in the paroxysm of that passion. If the forehead is crowded with horizontal wrinkles, it may indicate ferocity or severe mental application, but their entire absence can only be the effect of a cheerful disposition.

"If the frontal bone is convex," says Huart, "it indicates an undeveloped mind; all infants have such foreheads, and, under the influence of culture, the curve gradually disappears." Winckelmann indorses this notion, and thinks that the more straight lines the forehead exhibits the more judgment it will indicate, but at the same time so much the less sensibility. Wrinkles lengthwise between the eyebrows, Huart interprets as a sign of habitual melancholy reflections, and he, as well as Lavater and Redfield, believes that the prominence of the bone immediately above the eyebrows denotes aptitude for long-continued mental labor. "If asked what a *low* forehead denotes," Dr. Carus remarks, "I should say a vigorous scalp, or a predominating lateral development of the skull, but certainly not a low degree of intelligence"; and Horace went so far as to celebrate a *frons tenuis* as a sign of an ingenious mind.

"Gently arched eyebrows," says Campanella, "accord with the modesty and simplicity of a virgin; rough, irregular ones are the signs of ungovernable vivacity," and Dr. Redfield adds that on this point the physiognomists of all nations agree. If the hair of the eyebrows is thin or begins to fall out, Dr. Haller regards it as a sure

symptom of failing vitality; very heavy eyebrows, on the contrary, he takes to be a mark of redundant potency and reserved strength. "Eyebrows which join each other," Lavater remarks, "were considered among the ancients as a sign of a fallen character," but he himself inclines to Goethe's opinion that they denote *energische Sinnlichkeit*, which does not exactly mean sensuality, but rather active vigor of all the senses. The deficiency or abundance of eyebrow-hair he holds to be a physical rather than mental symptom, but owns that he "never saw a profound thinker, or even a man of a firm and judicious mind, with slender eyebrows, placed very high."

As to the eyes themselves, opinions differ to a rather perplexing degree. Their protuberance Gall, Lavater, and Fowler hold to be a mark of a retentive memory and language, i. e., fluency of speech, while Winckelmann and the Latin sages consider it as a sign of stupidity. A large eye the Greeks admired as the token of a large soul, but Gall and Dr. Carus see in it nothing but a large share of curiosity. The horizontal extension of the eye, if abnormal, Lavater suspects to be an indication of a designing mind; Redfield of excessive caution.

Their color, too, has been interpreted in very different ways. The ancients of Southern Europe, of course, preferred their own black eyes, and depreciated every lighter shade as sickly or even unnatural; but already, before their final subjugation by the Goths, they had learned to make an exception in favor of a blue iris, and we are told that, at last, even the dandies of the Roman capital envied the bright blue eyes and brown locks of Alaric. Gray and light blue, according to Le Brun, indicate coldness, but a German rhymed proverb calls a blue eye a pledge of good faith, and associates a gray one with deceitfulness. Brown, according to the same doggerel, bespeaks love of fun and mischievous merriment, while Spurzheim informs us that he found that color generally combined with a good-natured disposition. Only in regard to red eyes all nations and doctors agree: they are a sure sign of staminal weakness and degeneration.

In a treatise on physiognomy, the NOSE deserves a special chapter. "There is infinite expressiveness in every bone and every muscle of that prominent organ," says Sir Charles Bell, and proceeds to give us a long list of "indications," which may be summarized in the general remarks that he considers a long and pointed nose a sign of foxy slyness, a broad, short one a mark of a plain, practical mind, and Calmuck nostrils a symptom of frog-like stupidity. Redfield, too, locates "inquisitiveness" at the tip of the nose, and critical acumen in the next neighborhood, and quotes Aristotle, who speaks of the critical resources of a powerful and pointed proboscis.

In Seneca's language, an Athenian nose is a synonym for wit; and Horace introduces a wide-awake individual as a *homo emunctissimæ naris*, a man whose nasal ducts are in first-rate working order. Plato records his respect for a man with a *royal* nose, an article of which he

himself was a little short, though not to such a distressing degree as his master Socrates. Cæsar, Trajan, and the Abassides had such noses; also Henri Quatre and the founder of the Hapsburg dynasty. Rudolph von Hapsburg, though a righteous man and of peaceful disposition, so aggravated the German nobility by the size of his nose that his election to the imperial dignity gave general offense, and even men who had favored his nomination on account of his brilliant record were scandalized after meeting him face to face. But the emperor's judicious administration soon made his face so popular that he was besieged by portrait-painters, and once exclaimed in dismay: "God help me! Every fool who can draw a big nose wants to take my likeness!"

The Latins called such men *nasones*, and Ovid's influential family carried that name as a patronymic. Large hooked noses, according to Cuvier, Lavater, and Pernetti, indicate aggressiveness, love of conquest, and acquisitiveness, and their views are certainly supported by the abnormal development of those propensities among the ancient Romans and modern Jews. "When the aggressive instincts of the ancient Italians were suppressed," says Pernetti," "their noses shrunk to their present dimensions; exceptional individuals who have preserved the martial spirit of our ancestors are also conspicuous for their vigorous noses." The family of Napoleon must have preserved these characteristics in all their pristine vigor; his nose was as aggravating as his policy, and the shape of his chin was a triumph for Winckelmann's theory.

But, after all, such noses are preferable to the other extreme, the blunt hoggish snouts of the Calmucks and Southern Russians. A *nez retroussé*, a back-turned nose, the great Frederick considered as unpardonable in a soldier or any adult male of the Caucasian race, and was as proud of his own classic profile as of his best campaign. "God made the Roman, and man made the snub," says Dr. Wells, and Lavater demands a straight or *down*-turned nose as a *sine qua non* of a good face. "I never can look at a pug-nose without painful emotions," says he; "it makes it so sadly probable that our race has degenerated. I am sure Adam was not cursed with such a feature."

With a flat nose Gall associates sensuality and a groveling disposition; Dr. Redfield, also, want of energy and even of self-respect. But Zopyrus, the Athenian Spurzheim, went so far as to denounce a bulbous nose as a sign of a semi-bestial origin, and informed Socrates that one of his ancestors must have been guilty of an inhuman *mésalliance* of some sort, and that the shape of his nose "implied a tendency to drunkenness, theft, brutality, and lasciviousness"! It might be interesting to know what Zopyrus would have said about such noses as Gortchakoff's or ex-Senator Morrissey's, or the still greater deformity which made the face of Edward Gibbon a phenomenon.

The portraits of Socrates, in spite of that defect, exhibit a face

that might pass for intelligent and manly, if not for beautiful, in our days; but, in contrast with the living models of our classic statuary, the Mongolism of his features may have appeared more glaring. The Grecian profile, indeed, has always remained the *beau-idéal* of perfect beauty. "The proof that the straight profile constitutes beauty," says Michael Angelo, "is furnished by the effect of the deviating profile. The stronger the inflection of the nose the further the face deviates from its perfect form. The Grecian nose is the most human of all features; all other noses are a compromise with animalism."

These noses, as a national type, have utterly disappeared. According to Francisco Diaz, a Portuguese historian and philosopher of the eighteenth century, the last remnant of the favored race inhabited a district northeast of Cadiz, which neighborhood their Grecian ancestors had settled some two thousand years ago. They were peaceful tillers of the soil, but their adherence to the unitarian dogmas of Mohammed involved them in the fate of the wretched Moriscoes, who were expelled by order of the Rey Católico. We shall not look upon their like again.

The muscles about the mouth are mapped out like a town-chart by Dr. Carus, and for not less than eleven "qualities" he provides lodgings in that neighborhood. Love has the under lip all to himself, but four of his relatives, clemency, pity, the love of children, and benevolence, are crowded together in the narrow dell between the mouth and the chin. Five more inhabit the upper lip and the place below the nose, while cheerfulness has reserved seats in the corners of the mouth. Tumid lips must be a sure sign of sensuality, since nearly all physiognomical authorities insist on that thesis, and even Winckelmann, who commonly has an opinion of his own, is here, at least, neutral. He admits it to be a suspicious sign, but believes that after it has once become hereditary, as among certain African and South Asiatic tribes, it denotes merely a sanguine temper. But, if the upper lip protrudes so far upward that it fails to cover the teeth, the indication is even more unfavorable; it then means lasciviousness and stupidity combined. The habit some children have of keeping the mouth constantly open is also ominous of future imbecility, if we may believe Dr. Haller. Dr. Redfield's observation about prominent canine teeth has already been referred to; deformed (because decayed) teeth may indicate indolence (as implying a neglect of sanitary precautions), but are often hereditary, like weak lungs and short-sightedness. Short and white teeth in adults, as Lavater says, are frequently combined with uncommon bodily strength, and visible interspaces between the front teeth are a favorable omen of longevity.

That the art of mind-reading is yet in its infancy is sufficiently demonstrated by some of the "general rules" which, modern as well as ancient, physiognomists have recorded as the result of careful observation.

"The smallest heads," says Aristotle, "are generally stored with the largest share of sense, and the same rule applies to other extremities. If the hands and feet are small in proportion to the size of the trunk, it betokens a refined mind, a noble ancestry." Lavater would trust only to first impressions. "If I begin to analyze features," he confesses, "I am biased by my prejudices, and persuade myself to consider a head a bad one because it exhibits features which my pet theory objects to. But there are laws of compensation which assert themselves in the *tout ensemble* impression."

"In many faces I have seen an habitual expression which at first puzzled me," says Kant, "but I have found that by *mimicking* that characteristic look my mind involuntarily turns in the direction of that person's predominating passion, and thus furnishes me a key to the problem."

"How is it," asks Dr. Haller, "that crafty and designing persons use to keep one, or sometimes both eyes, half shut? and that only children and animals are honest enough to meet your glance with perfect unconcern? To other features I look for pathological indications, but the eye alone is the mirror of the mind."

Lord Byron, in matters of that sort perhaps a better observer, seems to have formed quite a different view. "Hold on, let me see the jaw," he called out, when Shelley's body was removed from the beach of Spezzia—"I can recognize any one by the teeth with whom I have talked. I always watch the lips and mouth: they tell what the tongue and eyes try to conceal."

"Let a beginner draw a head," says Le Brun, "and the face will always bear an expression of stupidity; never one of malignity or wickedness. Is not here an important hint? Stupidity, as expressed in mind or body, is *incongruity*, while in a scoundrel the mental machinery may be well arranged and very efficient, though working in the wrong direction. Mental turpitude can rarely be discovered in the features; mental derangement—which all foolishness more or less amounts to—very easily."

The comparison of some special rules reveals even stranger contradictions. Buffon, who himself loved a well-stocked larder, accepts *embonpoint* as a safe sign of mental health. "Crazy people," he informs us, "are always haggard; harmony of the mental and moral faculties is favorable to the development of fat." Redfield, with the same plausibility, demonstrates the exact reverse. "Only stupid brutes accumulate fat," says he, "oxen, sheep, and swine. Mental activity stimulates our torpid organs, but a sluggish brain induces physical inertia and fatty degeneration. . . . Dr. Swift," he adds, "was lean as long as he applied himself to letters; he afterward lost the main part of his reason and then became plump again." "A fat, short neck," says Pliny, "announces a mind ferocious," but Sir Charles Bell distinctly tells us that it indicates good-natured laziness and love of a

good table. But the difference in national standards of beauty is still more astounding. We know that Dr. Fowler's lectures made high foreheads so fashionable that New England exquisites spared no pains to promote their rapid development—not even those involved in the removal of a handful of hair; but the perfumed dandies of ancient Rome and Syracuse were just as anxious to cultivate a *frons parva et angusta*, which Ovid enumerates among the emblems of perfect beauty. Propertius, too, speaks of the *frons brevis*, the short forehead of a comely individual, and we are informed by Aristophanes that the ladies of Athens encircled their heads with a black ribbon, so as to make the forehead appear more narrow. "*Monstrum in fronte, monstrum in animo*," was a Latin proverb which certain political adversaries applied to the enormous forehead of the Dean of St. Patrick.

Galen informs us that "a great belly betrays a vulgar mind," while among the Turks beauty is chiefly a question of avoirdupois; and the Esquimaux, according to the Rev. Hansen, value abdominal prominence as the acme of manly dignity. Torngac, the old man of the sea, the hyperborean Jupiter, they think, will be distinguished among all the heroes and minor deities of his suite by his conspicuous belly and his prominent cheeks. Yankee Doodle seems rather to incline to Galen's opinion, though we have fat men's associations, and German communities where a jolly paunch is a potent element of popularity. The Gaelic mountaineers of the last century thought corpulence disgraceful; and Byron, according to his best biographer, was ultra-Scotch in this respect. "He resolved to keep down to eleven stone or shoot himself," says Captain Trelawney. "I remember one of his old acquaintances saying, 'Byron, how well you are looking!' If he had stopped there it had been well, but, when he added, 'You are getting fat,' Byron's brow reddened and his eyes flashed. 'Do you call getting fat looking well, as if I were a hog?' and turning to me, he muttered: 'The beast! I can hardly keep my hands off him!'"

The Esquimaux, as well as the Chinese and Calmucks, are shocked at the appearance of our noses; the latter speak of a proboscis or pelican's bill, if they wish to refer to the nasal organ of an Englishman, and admire the delicacy of their own stumps. But in mediæval France more than one gifted plebeian found a *nez retroussé* an obstacle to official advancement, and the *preux chevalier* valued a vigorous hook as one of his primary *insignia nobilitatis*. Montaigne, however, ridicules this taste, and suggests that a receipt for elongating noses by artificial means would make the fortune of the inventor: "*Quel bonheur de naitre avec un pied de nez!*"

We may realize the feelings of a Calmuck mother, who, shocked at the abnormal prominence of her offspring's nose, endeavors to improve his looks by flattening the offensive feature; but it is rather difficult to understand the taste of a lady who commences her toilet by

blackening her teeth!—yet this fashion prevails throughout Algeria, Tunis, and Tripoli.

It has never been fully explained how we came to be prejudiced against red hair, though Baron Bunsen suggests that it distinguished the aborigines of Northern Europe, whose descendants have survived in Jutland and Connaught, and that at a time when these F. F.'s resisted the inroads of the Indo-Germanic tribes, and every man's hand was against them, the aversion to their national characteristics, red hair and a freckled skin, became an instinct of Norman and Saxon nature. However that may be, the existence of the prejudice can not be denied, and, in certain border districts of Sleswig where yellowish-red hair has become hereditary, the local drug-stores do a rushing business in lead combs, which have been found to change the objectionable tint to auburn. But, when the Venetian Republic was in the zenith of its power, a considerable portion of the internal revenue was derived from a tax on artificial red hair, which had become a staple of commerce, and was bought and substituted for their own raven locks by all the fashionable ladies from Trieste to Fiorenza.

St. Paul asserts that "if a man have long hair it is a shame unto him" (1 Cor. xi, 14), and, with some phenomenal exceptions, our Caucasian contemporaries seem to share his opinion, though only a century ago North America and Western Europe indulged in perukes and pigtails of stately dimensions. But the Grecian aristocrats, from the days of Theseus to the accession of the Macedonian madman, sought to distinguish themselves by the length of their hair, as the Chinese mandarins by that of their finger-nails. When Alexander marched his troops against the Persian Empire, he insisted that his Grecian auxiliaries must submit to a wholesale shearing, as in a hand-to-hand fight their pendent tresses would give the enemy an unfair advantage; and Heinrich Heine is malicious enough to insinuate that the final abolition of the *Zopf*, the orthodox Prussian pigtail, was prompted by similar considerations. "If the old lady once had you by the Zopf," he says, "all resistance ended in an unconditional surrender."

[*To be continued.*]

THE FORMATION OF SALINE MINERAL WATERS.

By M. DIEULAFAIT.

As far back as we may go in the annals of mankind, we find mineral waters occupying a considerable place in the life of the peoples, and at last reach a point when they were the object of a veritable worship. Notwithstanding, however, the antiquity of the subject, and the importance that has always been attached to mineral

waters, with the immense variety of labors of which they have been the object, the fundamental questions relating to them still remain enveloped in profound darkness. An examination of the most recent and most authoritative publications suffices to show us that, with regard to the most capital point, the origin and mode of formation of these waters, we, at the end of fifteen centuries, are not much further advanced than were the Romans. Modern science, it is true, has put the ancient nymph to flight, and driven from his sanctuary the little beneficent god that presided at each fountain; but it has not yet succeeded in raising the statue of the truth upon the vacant altar.

Mineral waters take up the substances which give them their peculiar composition, and acquire all their medical value, at greater or less distances within the globe. It is, then, for geology, the science which deals with the formation of the globe, to seek the solution of the questions of their origin.

The number of mineral springs is immense, and the variations among them seem infinite; but there exist among them certain groups which distinguish and separate themselves at the first glance. Among these we place in the first rank the saline waters, or those of which the sea is the type. This is the division which I propose to consider, and of which I shall endeavor to set forth the origin and method of formation.

It is a fact, which I may state as uncontested at the present time, that all spring-waters, whether mineralized or not, are of exterior origin—that is, are waters of infiltration derived from the atmosphere. When these waters return to the light without having met, in the strata they have traversed, either soluble minerals or gases other than those of the atmosphere, they constitute ordinary waters. If, on the contrary, they have met soluble substances or gases different from those of the atmosphere, they will return more or less charged with those substances, and will then be mineral waters. In studying them we need not, therefore, inquire about the origin of the water itself, for it comes from the atmosphere, but only about that of the saline substances which it has encountered in its course.

It has been known from the most remote antiquity that considerable masses of saline substances, generally composed of gypsum, more rarely of rock-salt, exist at numerous points of our globe. The two salts we have named are the ones that have hitherto attracted the attention of commercial and scientific men; but the saline beds are in reality of a more complex composition than is superficially indicated by the predominance of those compounds.

The hypotheses which have been proposed to account for the origin of these salts, though many, may be grouped around three principal heads: 1. Free sulphuric acid, coming up from the depths of the globe, has acted upon carbonate of lime already formed and produced gypsum. 2. Hydro-sulphuric acid, coming in like manner from the

depths of the globe, has absorbed oxygen from the air, has become sulphuric acid, and, acting upon the already formed limestone, has produced gypsum, as in the previous theory. 3. Salts already formed in the interior of the globe have been brought up to the surface partly in solution, partly sublimed. These hypotheses are all wholly gratuitous; and, with regard to the first, it is impossible to admit that sulphuric acid, already formed, coming up from the depths of the globe, should have traversed, without saturating them, the enormous thickness of the underlying calcareous beds to make gypsum in the tertiary formation. The second hypothesis is more admissible, especially since M. Dumas has found gypsum that was evidently formed in that way; but while we may easily suppose a mass of limestone, of which one part has been transformed into gypsum by the action of free sulphuric acid, while the other part remains limestone, we can not admit such an intervention of the acid in a case where the gypsum is interpenetrated in all its parts with carbonate of lime. The third hypothesis, that the saline deposits have been brought up from the depths of the globe, is only a continued appeal to those mysterious actions which figure so prominently in the infancy of all the sciences; but, besides that it explains nothing, I believe that it is a real error. My studies of chemical geology have led me to the conclusion that the salts now held in solution in the waters of the seas, the salts existing in solid masses in the strata of our globe, and those which furnish the mineral constituents to saline waters, have a common origin, and that that origin is exterior to the first strata that were formed in the consolidation of the earth.

According to the conditions assumed in the nebular hypothesis of the origin of the earth, the rocks forming the first solid envelope of our globe solidified at a temperature of between 2,000° and 2,500° Cent. (3,600° and 4,500° Fahr.). Now, according to the law of dissociation, as discovered by Sainte-Claire Deville, chlorine, sulphur, and their constant compounds, with oxygen and hydrogen, were present in the atmosphere at the former temperature, and even below it, in a state of complete dissociation; and only at a much later stage than this was it possible for chlorine and sulphur to effect combinations so as to react upon the exterior crust and form sulphates and chlorides. The sulphates and chlorides, in their turn, could have been produced only at successive and extremely distant epochs. Thus, to mention only the two chlorides which constitute the largest part of the saline substances contained in marine waters, the chloride of sodium and the chloride of magnesium; the former has been formed at a high temperature, for it can support a high temperature without suffering decomposition. But the chloride of magnesium can not have been composed until a prodigiously more advanced epoch—that is, one nearer to our own time, when the temperature of the earth had descended to about the boiling-point of water; for the chloride of magnesium can not sup-

port such a temperature in the presence of water without being decomposed.

As the process of cooling continued, the atmosphere kept incessantly yielding by condensation the water which it held, and this water kept perpetually dissolving the soluble salts which it found already present, and also those that were continuously produced by the action of the acids it bore with it. As we have already seen, these salts were sulphates and chlorides. On the other hand, the metals competent to combine with the sulphur and the chlorine were necessarily those existing in the rocks that formed the first crust of consolidation, and these metals were, as we shall be able to show, lithium, potassium, sodium, magnesium, and calcium. Now, it is these five metals which, united with chlorine and sulphur, constitute nearly the total amount of the salts dissolved in the waters of the seas. Such, to my mind, is the origin of the salts which mineralize the seas; and it is an origin wholly exterior.* Thus, from the most ancient aqueous period of our planet, from the time when its external temperature was not notably below the boiling-point of water, and from a time, consequently, before any trace of life was possible, the seas have had essentially the same composition they have to-day. Zoölogists have for a long time regarded this fact as necessary, because the animals whose remains have been found in the most ancient sedimentary beds did not differ as to their general plan from their congeners in modern seas, and could not, consequently, have lived in waters that differed sensibly in composition from the water of existing seas.

If the whole mass of chlorides and sulphates was originally dissolved in the sea-waters, then the only way we have of explaining the origin of the saline formations which exist in the sedimentary beds is to assume that they have been left by the spontaneous evaporation of parts of the ancient seas accidentally isolated from the oceans. I came to this conclusion long ago, not by a more or less intuitive suggestion, but drawn to it by the logic of facts and the ideas I am about to present. This conclusion once formulated, I have taken the consequences, as numerous as important, which it involves, and have submitted them to an experimental verification.

In approaching the experimental side of my investigations, I had first to study in its details what takes place when the waters of existing seas are left to spontaneous evaporation.

First, a very weak precipitation occurs of carbonate of lime with a trace of strontium, and of hydrated sesquioxide of iron, mingled with

* An objection may be raised to this idea, from the fact that a large number of chlorides and sulphurous products are developed in modern volcanic phenomena which we all agree came up from a very profound zone. I refer to it to state that I am prepared to meet it and have elements sufficient to show that the two orders of facts are perfectly reconcilable.

a slight proportion of manganese. The water then continues to evaporate, but remains perfectly limpid, without forming any other deposit than the one I have mentioned, till it has lost eighty per cent. of its original volume. It then begins to leave an abundant precipitate of perfectly crystallized sulphate of lime with two equivalents of water, or gypsum, identical in geometrical form and chemical composition with that of the gypsum-beds. This deposit continues till the water has lost eight per cent more of its original volume, then all precipitation ceases till two per cent more of the original quantity of water has evaporated away. Then a new deposition begins, not of gypsum, but of chloride of sodium, or sea-salt. The separation between the end of the deposition of gypsum and the beginning of that of chloride of sodium is so marked that it is utilized on a grand scale in the works of the salt-marshes. The salters allow all the gypsum to be deposited in the ordinary basins, and then run the water thus cleared of gypsum into special vessels, whereby they obtain a pure salt, which they can collect down to the very bottom of the basin after the last mother-waters have been drawn off. The deposition of pure or commercial salt continues till the volume of the water has been again reduced by one half, when a precipitation of sulphate of magnesia begins to take place with it. This continues, the two salts being deposited in equal quantities, till only three per cent of the original quantity of water is left. Finally, when the water has been concentrated to two per cent, carnallite, or the double chloride of potassium and magnesium, is deposited. Spontaneous evaporation can not go much further. The residual mother-water will not dry up at the ordinary temperature, even in the hottest regions of the globe; its chief constituent is chloride of magnesium. A body of sea-water, evaporated naturally, will then leave a series of deposits in which we will find as we dig down the following minerals in order:

Deliquescent salts, including chiefly chloride of magnesium.
Carnallite, or the double chloride of potassium and magnesium.
Mixed salts, including chloride of sodium and sulphate of magnesia.
Sea-salt, mixed with sulphate of magnesia.
Pure sea-salt.
Pure gypsum.
Weak deposits of carbonate of lime, with sesquioxide of iron, etc.

The examination of this list and the facts that have been expounded draw with them a large number of consequences; I will only call attention to two of them. The first is, that the different groups of substances named in the list should become more and more rare as we ascend from the base to the summit; for each of them corresponds with a more advanced period of evaporation, and the chances for its production become less and less favorable as we rise. The second consequence—and I regard it as a capital one—is, that, when we meet one of the superior groups, we should expect to find, below it,

all the other groups which were deposited previously to it in the order of evaporation. These consequences are constantly verified in the saline beds which exist so numerously on the globe. Thus, to bring up again the two most important salts, numerous beds of gypsum are known, without rock-salt, or any of the other deposits, above them—which verifies our first conclusion; but no bed of rock-salt is known without gypsum—which verifies the second conclusion. More than this, a vast saline bed is now known which corresponds with the complete period set forth in our list—that is, with the complete period of evaporation; it is the formation at Stassfurt, Prussia, the disposition of which corresponds exactly with that shown in the list. The study of the Stassfurt bed further reveals an entirely new fact—the presence, in a part quite above the mean of deliquescent salts, of an important deposit of boracic acid combined with magnesium. All the geologists and engineers who have ever given their attention to the Stassfurt deposit have been unanimous in calling for volcanic intervention, and looking to the depths of the globe for the explanation of the origin of the boracic acid, and the place it occupies in the upper part of the bed; and they have all also given a more or less preponderant part to the play of volcanic agencies in the formation of the whole. This conclusion was the more natural, because the ordinary laws of chemistry seemed to oppose the probability of boracic acid, even if it existed, being found in the last mother-waters. Borate of magnesia is almost insoluble, and should have been among the first and lowest of the substances deposited. Adhering to the principle that there are no saline substances in the interior of the globe below the sedimentary formations, I silenced my protestations as a chemist, and applied myself to inquire if, contrary to all previsions, boracic acid did not exist in the ultimate mother-waters of the salt-marshes of the south of France. The result justified my geological induction to a degree beyond all possible anticipation. Not only does boracic acid exist in the ultimate mother-waters, but it exists there in a quantity relatively so considerable that a single drop of the water is enough to show it, either by the hydrogen method or by that of spectrum analysis. Thus, the presence of this substance in the upper part of the Stassfurt bed ceases to be an objection to the theory that the bed is purely and simply the result of the evaporation of the ancient sea-waters; and its presence here furthermore gives a confirmation, as striking as unforeseen, to that theory.

My chemical and experimental studies are very far from constituting the only foundation for my theory of the sedimentary origin of the saline formations of the globe. Existing nature offers us in abundance, and on even a vaster scale than was shown in the ancient ages, phenomena which it is sufficient to analyze to bring forth anew, even to the slightest details, the manifestations which accompanied and determined the precipitation of saline matters in the estuaries of the an-

cient seas. From among the numerous instances of this kind that present themselves to my thought, I select three—the mouths of the Rhône, the Caspian Sea, and the Dead Sea.

The map of the mouths of the Rhône shows that the lands for about twenty miles from the Mediterranean are cut up by numerous lakes, the principal of which, that of Valcares, exceeds sixty kilometres in superficial area. These lakes have been formed by the action of the alluvial contents of the river, which, being deposited on the bottom of the sea, have raised bars inclosing bodies of water. The water within the ponds, evaporating under the summer heat, is depressed in level. If the ponds were wholly isolated from each other, and had no communication with the sea, there would accumulate in each of them after a time, varying with its depth, a deposit of gypsum, and above this one of sea-salt, and so on through the series we have described; and, as the ponds are as a rule quite shallow, the saline deposits would all be thin. Things, however, do not go on thus. Most of the ponds communicate with each other and with the sea; consequently, when the water in them evaporates, the level is re-established with water that comes from the sea. In this way a pond, the bottom of which is only a few feet below the level of the sea, would become filled with saline substances if the canal of communication did not become choked. The Lake of Lavalduc, the surface of which is several yards below that of the Mediterranean, is depositing gypsum.

These facts show us saline deposits in process of formation under our very eyes, and it is not at all necessary, in order to explain their formation, to invoke changes of relief or any perturbations in the crust of the globe, but only to take an exact account of the manner in which a delta is formed, and of the circumstances that are a consequence of that mode of formation; and, although the delta of the Rhône is not one of the most extensive of the deltas of the modern period, it is one of the most remarkable and complete in respect to the spontaneous formation of saline deposits. If we should go into details, we should find a complete concordance between what is going on in the delta of the Rhône and what has been revealed in the study of the saliferous formations of past ages. Thus, saline deposits are forming in these more or less wholly isolated ponds: we have, then, a saliferous horizon in the delta of the Rhône, with the deposits generally separated; on the other hand, each of the deposits nearly always appears of a lenticular form, because the ponds of the estuaries necessarily, from the mode of their origin, assume that shape. The same principal characteristics are presented by most of the beds existing in the sedimentary deposits.

If, now, by any incident, a pond which has been closed and has deposited its gypsum is again brought into communication with the sea, life will reappear in it, and mollusks will leave their shells on top of the gypsum. If evaporation is resumed, life will disappear for a

second time, and new strata of gypsum will be precipitated upon the marls containing the marine shells. This condition is exhibited in the delta of the Rhône, where the Lavalduc Lake, which has been isolated from the sea for centuries, has sunk to fifteen metres below its level. It has a stratum of gypsum on the bottom, and above it is a thick formation of mud, that has become a true marl where it has dried, at the base of which, and at a level corresponding with the epoch at which the water was nearly normal sea-water, marine shells are abundant. It may occasionally happen that a marine estuary, in which a deposit of gypsum has taken place, shall receive an accession of fresh instead of salt water, and then we shall have deposits containing fresh-water fossils above the gypsum. We can see from this how valueless, as an argument against the theory that gypsums are products of the evaporation of sea-water, is the assertion, so often put forward in that guise, that gypsums are sometimes found covered with fresh-water deposits.

Similar phenomena and another illustration of our theory are exhibited on a colossal scale in the Caspian Sea. On the eastern side of that sea is the Gulf of Karabogaz, relatively small, but having a superficial area of at least twenty thousand square kilometres. It contains no living beings except some of the lower organisms, and its shores are marked by a complete sterility. Its only communication with the Caspian Sea is by a shallow channel which allows water to flow over from the sea, but lets none back. The excessive evaporation always going on in that hot and arid region causes a constant depression of the level of the water in the gulf, and this induces an incessant flow from the sea. In the absence of a counter-current from the Karabogaz to the Caspian, all of the salt that is brought in with the inflowing water remains in the Karabogaz; the amount of salt thus regularly added to the quantity already held there is not less than three hundred and fifty thousand tons every twenty-four hours. It is easy to prognosticate the future of this gulf. If the channel of communication is kept open, the water, now nearly saturated, will continue to deposit gypsum; but the constant accession of water from the sea will prevent its reaching for an extremely long time the degree of concentration that will permit the deposition of salt. There will in this case be produced in the Karabogaz a colossal deposit of gypsum, to which no parallel can be found in the ancient formations. If, on the other hand, the channel becomes obstructed, evaporation in the Karabogaz will go on more rapidly, for it receives no important affluent of fresh water. Then, at the end of a time which will not be prodigious, we shall have a saline deposit identical with that of Stassfurt, having large masses of gypsum at the bottom, and deliquescent salts with boracic acid at the top. The latter ending is more likely to be realized; for the level of the Caspian Sea itself is falling under the excess of evaporation over the supply of water brought by the rivers into it, and will at no very dis-

tant period sink below the level of the bottom of the channel that connects the Karabogaz with it.

The character of the Dead Sea is still in question. M. Lartet, of Toulouse, who was connected with the expedition of the Duc de Luynes in 1866, fully recognizes the close analogy of its waters with the mother-waters that are left from the evaporation of the waters of normal seas; but he believes that its waters owe their quality to thermal springs, and that the sea never could have been in communication with the Mediterranean or the Red Sea. He supports his view by the assumed absence of certain substances common to sea-waters from its waters; but, as I have found these substances by analysis in Dead Sea waters, I consider the argument resting upon that ground invalid. M. Lortet, of Lyons, has recently made a discovery that indicates that this lake once formed part of a normal sea. He has found near the Lake of Tiberias a plateau covered with gravel and rounded pebbles, situated at the exact level of the Mediterranean Sea. If the body of water that washed these gravels and pebbles once occupied the valley of the Jordan and the Dead Sea, then there once existed here a gulf like that of Karabogaz. Separated from the oceans by some accident, it has dried up; its less soluble salts have been gradually deposited in the shallower parts of the basin and constitute the saline masses which are now found in the region—products of the sea instead of being the causes of its saltness; and the deliquescent salts have become concentrated, as in modern estuaries, into the still liquid part that constitutes a mother-water fully comparable in all respects to the mother-waters of the salt-marshes of the south of France.

I conclude with a summary of the principal facts to which I have directed attention.

At the moment when the first crust of consolidation began to form around our globe, chlorine and sulphur, now existing in combinations, were in the atmosphere. When the temperature had sufficiently diminished, these two bodies, reacting on the exterior crust of our globe, formed, at intervals otherwise extremely distant, combinations (sulphates and chlorides) by uniting with the metals that existed and still exist in the rocks constituting that first envelope. These metals, combined almost exclusively with sulphur and chlorine, are precisely the ones (lithium, potassium, sodium, magnesium, calcium) that still mineralize the waters of the seas. The salts thus formed, dissolved in the waters from the most ancient age of the aqueous period of our planet, have, then, a wholly exterior origin. Later, under the influence of causes often extremely insignificant in themselves, parts of these seas have been isolated from the oceans; they have evaporated, and, according to the degree of completeness in which concentration has been effected, they have deposited salt-beds sometimes of a complex enough nature, but which have uniformly presented the typical character that they begin with deposits of gypsum. Such is the origin of

the saline masses that exist in the interior of our globe. Whenever waters of infiltration reach these saline deposits, they dissolve more or less considerable quantities of them, and, when they come out again into the light, they constitute what are called saline mineral waters.

A PARTNERSHIP OF ANIMAL AND PLANT LIFE.

BY K. BRANDT.

THE fundamental difference in the feeding of plants and animals is conditioned on the presence or absence of chlorophyl. Green plants are competent to assimilate inorganic matter by means of the chlorophyl-bodies in their leaves, while animals require organic substances for food. Were this difference mere comprehensive, it would incontestably be regarded as the most important of all the differences between the two classes of organisms. But there are, on the one hand, plants that have no chlorophyl—the fungi; and, on the other hand, animals which have been known for a considerable time to contain chlorophyl, as the fresh-water sponge (*Spongilla*), the hydra, several gyrating moners, and many infusoriæ and rhizopods.

The fungi feed, like animals, on organic matters; but it is not yet sufficiently established whether the so-called chlorophyl-bearing animals can be nourished entirely after the fashion of real plants, by the assimilation of inorganic matter; or, in other words, whether, with an abundant access of air and suitable lighting, they can live in filtered water. Before we can approach this question more closely, however, we must decide another equally important one, whether the chlorophyl-bodies present in the animals are really elementary parts, morphologically corresponding with vegetable chlorophyl produced by the animals themselves, or whether they are not unicellular vegetable organisms parasitic in the animals—in other words, it must be decided whether the green bodies in animals are parts of cells or are themselves cells; whether they are morphologically and physiologically dependent on the tissue in which they appear, or independent of it.

Morphological investigation has been pursued upon hydras, spongillas, a planaria, and a number of infusoria, from which the green bodies have been pinched off and examined with strong magnifying powers. All the examinations of these different objects have given the uniform result that the green bodies of animals are not evenly green like the chlorophyl-bodies of plants, but contain colorless protoplasm besides the green mass, or, at least, a cell-kernel which can be easily distinguished on treatment with hematoxylin. Among them were likewise several cell-kernels, which were regarded as evidences of the beginning of division, for normal chlorophyl-cells never contain a cell-kernel.

Thus the green bodies of animals do not correspond with the chlorophyl-bodies of the algæ, but are independent organisms, or one-celled algæ, which have been named *zoöchlorella*. Yellow cells are found living under similar relations in actinias and radiolarias, which have been distinguished as *zoöxanthella*.

The physiological as well as morphological independence of the green cells is also demonstrated by the fact that when separated from the animals they continued to live in this condition for days and weeks, and formed starch in the sunlight. When grafted upon hydras and infusoriæ, which were quite free from chlorophyl, they continued to live upon them.

The conclusion is drawn from these researches that self-formed chlorophyl is wanting in real animals, and that, when it is present in their bodies, it originates in plants that have immigrated to them. The most interesting result from them is the answer they give to the question as to the significance of the green and yellow algæ to the animals in which they occur. In order to examine this matter more closely, colonies of radiolarii containing numerous yellow cells were put into filtered sea-water. They not only continued to live in it, but outlived the specimens that were left with the other organisms. Now, since the radiolarii are real animals, incapable of living on any but organic matter, while in this case air and water afforded them all the support they required, they could have been kept alive only by the yellow cells that lived upon them, working up the inorganic substances that were provided for them, under the influence of light, into organic. Further experiments showed that fresh-water sponges could be cultivated to the best advantage in filtered water, thus demonstrating that the *zoöchlorella* and the *zoöxanthella* are fully competent to maintain the animals in which they live. If the animals contain few or no green or yellow algæ, they are fed, like real animals, by the assimilation of solid organic matter; but, when they contain algæ, they may be fed, like real plants, by the assimilation of inorganic matter. In the latter case, the algæ living in animals perform precisely the same function as the chlorophyl-bodies of plants.

PROFESSOR RUDOLF VIRCHOW.

PROFESSOR RUDOLF VIRCHOW is almost equally well known as the leader of one of the principal German schools of scientific thought and as a prominent actor in the field of German politics. In the former capacity his name is inseparably associated with the theory of cellular pathology, which he first expounded and which he has maintained with eminent consistency; in the latter character he has gained an honorable fame as a faithful guardian of the municipal in-

terests of the city of Berlin, and as a brave and outspoken parliamentary leader on the side of liberality and progress.

Professor VIRCHOW was born at Schievelbein, in Pomerania, on the 13th of October, 1821. He studied medicine at the Frederick-Wilhelms Institute in Berlin, and was graduated in that faculty from the University of Berlin in 1843. He was made prosector of the Charité Hospital in 1846, and in the following year was appointed a regular lecturer in the university. In 1848 he was commissioned by the Government to visit Upper Silesia and study the typhus fever which was prevailing there as an epidemic, the result of misery and starvation. His report on this subject commanded attention at once, and is still held in high esteem by the medical profession and by all who are concerned with sanitary science.

To this period of Virchow's life belongs the establishment of the "Archiv für pathologische Anatomie und Physiologie und für Klinische Medicin," which was founded by Virchow and Reinhardt in 1848, and has been continued by Virchow since Reinhardt's death in 1852; and of the "Medical Reform," which he conducted in connection with Leubuscher in 1848 and 1849. The "Archiv" is still continued under Virchow's direction, and is recognized as one of the chief and authoritative medical journals of the world. To this period belongs also his entrance into active political life on the awakening of his republican enthusiasm by the revolutionary movements of 1848 and 1849. He formed a democratic club, became a popular orator, and was elected to a seat in the National Assembly, to which, however, he was not admitted, because he had not yet reached the age of eligibility. The reaction came on, and Herr Virchow, whose participation in the revolutionary movement was not agreeable to the powers whom it displaced for a time, and who had the control of the public positions he held, was removed from his lectureship. He could not, however, stay dispossessed; the medical societies insisted upon his recall, and he was reinstated by the force of his obvious fitness for his position. He accepted an invitation to the chair of Pathological Anatomy at the University of Würzburg, and removed there. The Government, however, could not spare him from Berlin, and Herr Manteuffel called him back to his old chair in the university in 1856. He then became director of the newly founded Pathological Institute, and soon raised it to the first rank among such establishments, and made it a center of independent investigations for numerous young students. While at Würzburg he published his "Collection of Contributions to Scientific Medicine," of which the leading paper, on "The Movement in Favor of Unity in Scientific Medicine," which, previously published separately, had already attracted much attention from the scientific world, revealed the tendencies and direction of thought by which his subsequent career was to be determined. Professor Virchow's most distinguished services to science have been given in the

field of pathological anatomy, in which he is generally recognized as the founder of the theory of cellular pathology. The character and value of his work in this field are reviewed by Professor Jacobi, of this city, in his address before the New York College of Physicians and Surgeons. He remarks that, before and about the time when Virchow was preparing to commence his career, medical science in Germany was by no means independent and self-governing. There was no country in Europe in which observation and regard for facts, and facts only, were less esteemed than in Germany. England had enjoyed a predilection for pathological anatomy since John Hunter. France had lived through its most brilliant medical career, and could show a roll of illustrious, sober, and painstaking men, whose successful labors had placed the medical science of that country far above the level of any other. "Meanwhile, German medicine was controlled by what was called philosophy, and mainly by the so-called philosophy of nature. . . . Everything in medicine, not accepted because it was old and traditional, was a matter of speculation *a priori* only. The bases of speculation were premises construed by reasoning, not founded on facts; by theories not built on experience, far less on experimentation. Both facts and experimentation were claimed by Virchow as the only admissible foundations of scientific medicine, no matter how long it would take to collect them or to establish them. At the same time he was perfectly well aware that the literature of the last two thousand years contained a great many available points; nobody ever was more honest in collecting material or giving credit."

Virchow wrote in the first volume of his "Archiv," in 1847: "We ought not to deceive ourselves or each other in regard to the present condition of medical science. Unmistakably, medical men are sick of the large number of new hypothetical systems which are thrown aside as rubbish, only to be replaced by similar ones. We shall soon perceive that observation and experiments only have a permanent value. Then, not as the outgrowth of personal enthusiasm, but as the result of the labors of many close investigators, pathological physiology will find its sphere. It will prove the fortress of scientific medicine, the outworks of which are pathological anatomy and clinical research."

The cell had been discovered to be the fundamental basis, by Schleiden, of the vegetable, and, by Schwann, of the animal tissues. Virchow, after a series of observations and experiments, became convinced that the cell had the power of propagating and multiplying itself within the individual, and proved that it is the physical body "with which the action of mechanical substance is connected, and within which the latter can retain its functions, which alone justify the name of life. Whatever outside of the cell acts upon it, works a mechanical or chemical change within it, which change is disorder or disease." The external cause may excite a reaction within the cell, when it works as an irritant, or it may go without reaction, when it

is a simple lesion or a source of paralysis, the difference in results being dependent upon a difference in the condition of different cells. This difference in the condition of the cell forms its predisposition. Previous to this, the old humoral theories which regarded the whole compound mass had held more or less sway in medical practice, and the recognition of diseases as local anomalies had made but slow progress. A few workers, from Vesal and Paracelsus down, had gradually given shape to the local theory, and Virchow claimed that his cellular pathology was a consistent carrying out of the principles they had established. In it the localization of disease was taken as a necessity, and its seat was fixed in the smallest composing element, or the cell. Therapeutics have also undergone important changes in the light of this theory, and under the guidance of experimental methods, and have become vastly more exact and efficient, and local in application. Thus far, Dr. Jacobi asserts, every new discovery of pathological facts has found a ready explanation by the cellular theory and its methods. "The changes worked in and by the white blood-cells, the transmutation of epithelial cells into benign results or malignant growths, the influence, real or imaginary, worked by bacteria, have but strengthened its plausibility."

An antagonism to Virchow has apparently been assumed by some of the partisans of the bacterial theory of infectious diseases which has no real basis for existence. No discrepancy need exist between a theory which regards disease as a disorder of the cells and the one which finds in the bacteria an external agency provoking and promoting cell-disorder. The publication of an essay on parasitic plants, in the first volume of Virchow's "Pathology and Therapeutics," in 1854, shows that his attention had been directed to the subject even then. In 1856, also, a paper was published by him, in the "Archiv," on the botanical nature and classification of some forms of parasites to which an important part in nosology was to be attributed, on which occasion he invented and first used the term "mycosis," which has since been generally adopted. Brauell's papers on the bacterial parasite of anthrax, following up the researches of Davaine and Pollender, appeared in the eleventh and fourteenth volumes of the "Archiv," and were followed by numerous papers in that and other journals. Obermeier found the *spirochæte* in the blood of relapsing fever, in Virchow's hospital division, in 1873.

Virchow himself has said on this subject, in answer to an attack by his former pupil Klebs: "Vegetable and animal parasites are among the causes of disease. Their place is in etiology, and therefore it is easily conceived that, as Klebs expresses himself, they found no place in my cellular pathology. There it was not any more my domain to offer an extensive paper on parasites than it was to treat of traumatic injuries and corrosions. In my cellular pathology I meant to demonstrate the changes which take place in the elements of the

organism in the general forms of disease. Thus, I meant to build up a theory of the essentiality of disease. Specific causes were mentioned only as examples—for instance, intoxication; and, though but briefly alluded to, parasites have not been entirely overlooked."

His attitude toward Darwinism has been likewise misapprehended. Far from being an opponent of Darwinism, he should be regarded as one of its forerunners, for, as early as 1849, in his "Movement in Favor of Unity in Scientific Medicine," he spoke of the origin of life as a mechanical necessity; and in 1858, a year before the publication of Darwin's "Origin of Species," he pointed, in an oration which was afterward printed in 1862, with three other orations on "Life" and "Disease," to the changeability and transmutability of species as a necessary basis for the mechanical theory of life. But, when Haeckel insisted upon the inclusion of the theories of natural selection among the subjects to be taught in the public elementary schools, Virchow objected that only established facts and results, not theories, should be taught in the public schools.

To Haeckel's contradictions of religious faith Virchow is able to return a tacit answer, by adhering to what he wrote more than thirty years ago, that "faith does not admit of a scientific discussion, for science and faith exclude each other. Not to such an extent, however, that one of them renders the other an impossibility, but in such a way that, within the range of science, there is no place for faith; and the latter can commence only where the former ends. It need not be denied that, if this boundary-line be respected, faith may have actual objects. It is not, therefore, the domain of science to attack faith or its objects; but its duty is to mark and consolidate the present termination of knowledge."

Among the earlier papers written by Virchow and published in his first collections were some on different features and diseases of the skull and brain. These were followed by other cranial studies, and thus the physician was led to the study of anthropology, archæology, and paleontology. He was one of the founders of the German Archæological Society, which was organized at the meeting of the German naturalists at Innsprück in 1869, and he became the president of the society in 1870. He has also been the leader of the Berlin Anthropological Society since 1869, and has himself undertaken extensive and important researches. Having become engaged in a controversy with Quatrefages respecting the origin of the Prussian race (Quatrefages maintaining that it was of Finnic descent), he instituted those investigations, among the school-children of Germany, into the relative prevalence of blondes and brunettes, which have proved very interesting in their progress and results, and which have been taken up in other states. As a member of the Academy of Sciences, to which he was elected in 1873, he read important anthropological papers in 1875 and 1876; and in the latter year delivered an address at the meeting

of the German naturalists on the present position of anthropology, in which he maintained that that branch, although one of the youngest of the sciences, already occupied as advanced a position as many of the older branches of study. He opposed the idea that the people now lowest in development must necessarily fade away when they come into contact with civilization, and showed that it was contradicted by the history of the Europeans themselves. If the civilized people of the present day be considered as the product of a higher development, he said, we can not regard the possibility of such a development as a cause of the extinction of such people as are now on the same platform of culture which we ourselves once occupied. He took an active interest in the investigations of Dr. Schliemann in the Troad, and spent some time there, participating in the work, in 1879. He gave particular attention to the formations of the swamps in the neighborhood, and of the building-stones, and showed that they were all of fresh-water origin, thus conclusively putting to rest, it was held, the objections of those who, opposed to the view that Hissarlik represented the site of ancient Troy, that, at the time of the Trojan war, the place must have been covered by the sea, or too near it to permit the movements described in the Iliad. While here, he gave valuable medical aid to the people of the region.

Professor Virchow has labored actively for the spread of scientific knowledge among the people. He was for a long time a member of the body of instructors to the Berlin Workingmen's Union, and in that capacity published, in connection with Holtzendorff, a collection of popular scientific treatises.

The scientific side, although there is enough of it to fill up an ordinary human life, is only one side of Professor Virchow's career. His life is equally full on the political and practical side. Since 1859 he has been an alderman of the city of Berlin, and has in that capacity given conscientious attention to the details of the government and wants of the municipality. In direct reference to this office he has written many papers on subjects of hygiene, drainage, and sewerage, marked alike by scientific thoroughness and by adaptation to local wants. He was elected a member of the Prussian Chamber of Deputies in 1862, having the choice between the seats for three constituencies offered to him, and has served in that body with distinction ever since. He at once took the lead among those who opposed the arbitrary measures of Bismarck and his despotic assumptions; and has continued one of the most vigorous and formidable antagonists of that minister. In January, 1863, he proposed and secured the acceptance of an address accusing the ministers of having violated the constitution. In 1865 his opposition was so energetic that there was talk of Herr Bismarck's challenging him to a duel. He did not, however, assume an extreme democratic position, but accepted the constitution with the reservation of the right of protest against objectionable measures which might be pro-

posed under it. The events of 1866 cast his party into the shade for a time, but he gradually resumed, in the enlarged Prussia, his opposition to the measures of military rule and centralization. In 1869 he made a proposition in favor of an international disarmament, which was of course rejected. He was elected a deputy to the Diet of the North-German Confederation, and afterward of the German Empire, but declined both calls on account of his objections to the constitutionality of those political creations. He, however, consented to enter the Reichstag in 1880, as a member from one of the conscriptions of Berlin. He was the author of the expression "*Kulturkampf*"—battle for culture—in connection with the controversy with the papal power, which was so long a political watchword in Germany. His political work, well performed as it was, was never allowed to interfere with his scientific pursuits, which he regarded as his proper and serious labor, but it often appeared to him, he says, "to be rather a recreation than otherwise." In 1872 he replied with a refusal to an invitation by a German society to withdraw from the French scientific societies of which he was a member, declaring that a rupture of the scientific relations between the two countries would be contrary to the interests of civilization, of science, and of humanity. He was a member of the Sanitary Associations of Berlin during the wars of 1866 and 1870, organized the first Prussian sanitary train, and had a part in the organization of several military and other hospitals. He is the author of new laws in reference to the contagious diseases of animals and to fisheries. Last year he was one of the speakers at a public meeting to do honor to the memory of our murdered President, James A. Garfield.

Professor Virchow's published works are numerous. A large proportion of them consist of special papers on medical subjects, many of which have appeared from time to time in the "Archiv," or are included in the two collections of "Contributions to Scientific Medicine" (1857) and "Treatises connected with State Medicine and Epidemiology" (1879). Important studies of prevalent disorders and epidemics are embodied in his report on the famine in the Spessart (Bavaria), the typhoid fever in Silesia, and leprous affections in Norway, and in his essays on cholera and trichinosis. His "Cellular Pathology," which forms the first volume of his "Lectures on Pathology," in four volumes, has been translated into several languages. "The Pathology of Tumors" (three volumes, 1863–1867) is the most exhaustive and comprehensive work on that subject. Works of a more general character are "Goethe as a Naturalist" (1861), "National Development and the Importance of the Natural Sciences" (1865), "The Education of Women for their Vocation" (1865), "The Problems of the Natural Sciences in the New National Life of Germany" (1871), and "The Liberty of Science in the Modern State" (1877).

EDITOR'S TABLE.

MATTHEW ARNOLD ON LITERATURE AND SCIENCE.

It was hardly to be supposed that Professor Huxley's address at the opening of Sir Josiah Mason's College would be left without some attempt at a formal answer. The bare establishment of a collegiate institution, from which "mere literary instruction" was excluded, was not in itself very important, as it is not expected that mechanical, technical, and industrial schools will give much attention to literature at any rate. But when literary education, as a method of culture, was attacked as narrow and inadequate, and another method more liberal, more efficient, based upon science, and claiming superiority upon that ground, was forcibly presented so as to elicit extensive assent, the challenge to the devotees of literary cultivation could not be passed by.

In this crisis, Mr. Matthew Arnold comes forward as the champion of literature. His position was recognized by Professor Huxley as among the foremost in English literature, and he quoted from him the positions to be contested. Mr. Arnold was therefore in a sense called out, and he has made his response in an address before the Cambridge University, which we reprint from the "Fortnightly Review." We are interested in seeing how an eminent literary man deals with the two methods of study, and from this point of view the discussion will justify some comment.

Mr. Arnold first deplores what he considers the crusade of science against literature; and then tries to make out that, properly considered, there is no ground of controversy. But, because he does not or will not see the other side, is not a sufficient reason for denying its existence. There is undoubtedly a broad issue at the present time between literature and science, as distinctive methods of mental culture. The literary method grew up and was carried to great perfection by the creation of the masterpieces of literary art long before science appeared. That method has continued to the present time as a separate influence, and with a distinctive ideal in the traditional systems of education. It is undeniable that, as our colleges are constituted, a liberal, classical, literary education can be obtained with but very little knowledge of science, and it is notorious that great multitudes acquire a comprehensive literary culture while remaining as ignorant of the sciences as they would have been in the scholastic ages. If there is to be any comparison of methods, their characteristics must be limited and defined, and certainly there is no difficulty in distinguishing the quality of literary cultivation.

Mr. Arnold had said, "In our culture the aim being to know ourselves and the world, we have, as the means to this end, to know the best that has been thought and said in the world." It is fair to infer that the word "best" is here to be interpreted by the literary standard—not by *everything* that has been thought and said, but by the "best," that is the choicest, the finest, the most excellent, as found in the supreme literary performances of both the ancient and modern mind. That this was Mr. Arnold's meaning is evident from another passage quoted by Professor Huxley. He says: "Europe is to be regarded as now being, for intellectual and spiritual purposes, one

great confederation bound to a joint action and working to a common result; and whose members have for their common outfit a knowledge of Greek, Roman, and Eastern antiquity and of one another. Special local and temporary advantages being put out of account, that modern nation will in the intellectual and spiritual sphere make most progress which most thoroughly carries out this programme."

From this Professor Huxley dissents and declares that he finds himself "wholly unable to admit that either nations or individuals will really advance, if their common outfit draws nothing from the stores of physical science. An army without weapons of precision, and with no particular base of operations, might more hopefully enter upon a campaign on the Rhine, than a man devoid of knowledge of what physical science has done in the last century upon a criticism of life."

To this Mr. Arnold replies by flatly repudiating the accepted interpretation of the scope of literary culture; he would even so widen it as to include all science. He says: "When I speak of knowing Greek and Roman antiquity as a help to knowing ourselves and the world, I mean more than a knowledge of so much vocabulary, so much grammar, so many portions of authors in the Greek and Latin languages. I mean knowing the Greeks and Romans, and their life and genius, and what they were and did in the world. . . . By knowing modern nations, I mean not merely knowing their *belles-lettres*, but knowing also what has been done by such men as Copernicus, Galileo, Newton, Darwin." And further, "in the best that has been thought and said in the world, I certainly include what in modern times has been thought and said by the great observers and knowers of nature." That is, science disappears as a separate intellectual interest by its complete absorption in literature: neat but unsatisfactory.

Mr. Arnold is quite aware of his disadvantage in dealing with Professor Huxley, who is strong in both literature and science, and he repeatedly refers to the slenderness and deficiency of his own scientific attainments. But, had he been more perfectly aware of them, he would hardly have ventured upon this mode of escaping from the issues that have arisen between literary and scientific culture. Had he better understood what is meant by the scientific method, he would not have tried to stretch the literary method so as to embrace and incorporate it.

Without asserting that the relations of these two methods of culture are essentially antagonistic, it remains true that they are so profoundly different that they are not to be confounded or identified. By literature we mean, and rightly mean, the study of books of language, of the arts of expression and criticism, and familiarity with the most perfect written productions, as such, whether in prose or poetry, that have been produced in all time. And literature as a method of mental culture is simply a training in these various acquisitions and exercises.

But the scientific method which has arisen in modern times began in an open and declared revolt against this mode of occupying the human mind. It involved new objects, new procedures, and new disciplines of thought. Seeing that the mind for ages had been arrested at verbal studies, and had failed in the production of solid knowledge, men began to demand an advance to the actual study of things. This is the essence of the scientific method, and it has achieved its great results only by repudiating the old literary occupations, and proceeding directly to the research of nature. The sciences have arisen, knowledge has been extended, power over nature conferred, and a new civilization created only by concentrating thought upon the realities of experience instead of studying

nature, life, and man, as they are represented in literature. To incorporate the scientific method with the method of literature is impossible; to subordinate it to that method is to destroy it. That which is obtained from books alone, without an acquaintance with phenomena, is not true science but sham science. Scientific culture is a training and a grounding in the scientific method, a mental habit of observing, analyzing, and comparing the actual facts, and the advantages of this method can only be gained by a distinctly recognized, independent, and systematic culture.

How different and how contrasted the literary and scientific methods really are, becomes again apparent when we observe the feelings to which they respectively give rise. Mr. Arnold continually refers in his article to two elements of human nature to be satisfied by culture, the sense for beauty and the sense for conduct; but he nowhere speaks of the sense for truth, and this, obviously because truth, as an object of feeling, does not enter into the literary ideal. It was, in fact, because literature as a method had never cared for truth, and had no interest in the search for it, that the need for science arose to repair the omission; and science has only advanced as the feeling for truth has been developed and deepened. To the man of letters, devoted to the beautiful, the fine in art, and the pleasing in life, the scientific passion for truth is unintelligible and very naturally repugnant. The annals of literature are full of the aversion of its cultivators to science and all that belongs to it. The last example is given by Mr. Boyesen, who talked much with the poet Longfellow, and has printed some of his chronicles in the "Christian Union." He says of Mr. Longfellow: "The scientific questions which agitate the intellectual atmosphere of the century also left him cold; and if they were touched upon in his presence he soon showed by the vagueness of his answers that the topic was not congenial to him. His thoughts moved in a purely literary sphere, and I believe I do him no injustice if I say that life interested him primarily in its relation to literature. He was of opinion that Goethe made a mistake in devoting so much of his energy to scientific pursuits, and that his later works (particularly 'Elective Affinities' and his second part of 'Faust') were much injured by the influence of his scientific theories." This dislike of science means nothing more than intense devotion to an ideal that is foreign to science. But, on the other hand, the scientific ideal gives rise to emotions of its own, of equal if not even greater intensity. The history of science has proved that the love of truth is one of the strongest passions of human nature. It has abundantly proved that men will forego all the lower and common enjoyments of life, when that becomes necessary, to promote the attainment of truth. So powerful may this feeling become that the customary selfish pleasures and ambitions of men seem trivial and contemptible in comparison; and who will say that this love of truth, which is the inspiration of the scientific method, is not the noblest impulse that can animate the mind of man?

But, when half through his address, Mr. Arnold *does* find an issue between literature and science. He says: "But it is proposed to make the training in natural science the main part of education, for the great majority of mankind at any rate. And here, I confess, I part company with the friends of physical science, with whom, up to this point, I have been agreeing. . . . At present it seems to me that those who are for giving to natural knowledge, as they call it, the chief place in the education of the majority of mankind, leave one important thing out of their account, the constitution of human nature." Knowledge, he admits, is interesting, and much of it important, but it

comes in fragments, and Mr. Arnold thinks there is something in human nature that desires "to relate these pieces of knowledge to our sense for conduct, to our sense for beauty." And again: "We feel, as we go on learning and knowing, the vast majority of mankind feel, the need of relating what we have learned and known to the sense we have in us for conduct, to the sense we have in us for beauty."

But, if Mr. Arnold had gone on to say and to the sense we have in us for truth, he would have struck an element in human nature more potent than any other for bringing the disjointed fragments of knowledge into harmony and unity. It is that use of the faculties which has led to the creation of knowledge which must be trusted to bring it into the most perfect relations. Mr. Arnold parts company with science in the name of the demands of human nature, but our first demand concerning human nature is that it shall be understood. Literature never explained it—could not explain it, because the study of principles and laws, and the decomposition of complex things into their elements, and finding out the truth, were not embraced in its method. In parting company with the students of science on such grounds, Mr. Arnold virtually concedes that they have a method of their own, though a method which he can not approve. He raises the issue of superiority, but he does not settle it. He expatiates on the utilities of literature, but he offers no proof that its past ascendency is still justified, because he seems to have no true or adequate conception of the claims of the scientific method. We point, on the other hand, to what science has done for mankind as evidence of the greater things it may yet be expected to do, and to the soundness, comprehensiveness, and thoroughness of the training which it enforces in proof of its superiority in the preparation of men for the intelligent discharge of their duties to themselves, to their families, to society, and to humanity.

THE MONTREAL SCIENTIFIC MEETING.

The American Association for the Advancement of Science held its annual meeting this year in Montreal, under the able presidency of Dr. J. W. Dawson, Principal of McGill College, and eminent as a geologist and paleontologist. The gathering was large, the various sections were strongly represented, and the labors of the scientific body every way successful. A large number of papers were registered, many of them important, and they were got well through with, notwithstanding the tendency to consume time in their discussion.

The American Association met at Montreal twenty-five years ago, and had an excellent convention at that time. But the changes of a quarter of a century have been marked. Strong men have passed away, and new men of no less promise have taken their places. Old scientific questions have taken on new aspects, and new questions have come to the front. The city whose hospitalities were so liberal in 1857 has become a much larger and more beautiful city in the interval, and the generous reception given to the large body of strangers shows that the prosperity of Montreal has not been at the expense of its liberal spirit and hospitable feeling. We print the excellent address of Professor Brush, given upon his retirement from the presidency of the Association. His theme was well chosen, and, if less ambitious than those frequently taken on these occasions, it was none the less instructive and important. Mineralogy is not one of the show sciences, that attract much popular attention, but it is a science of profound interest and great economic importance, and Professor Brush could not have chosen better than to give us this admirable account of its American progress.

LITERARY NOTICES.

Natural Religion. By the author of "Ecce Homo." Boston: Roberts Brothers. Pp. 251. Price, $1.25.

This little book, by Professor J. R. Seeley, of the Cambridge University (England), deserves the most serious consideration on the part of all who care for the higher questions of modern controversy. Some of its chapters first appeared in "Macmillan's Magazine," and were reprinted in the "Monthly," while the author's name was unknown. But they were evidently by a man of power, insight, independence, and great catholicity of spirit; and they handled the exciting and even the exasperating questions of the time, not only with a striking originality, but with a forecast of new agreements most encouraging to all who are concerned about the religious progress of mankind. The great distinctions and differences over which people are quarreling and disputing in the religious and anti-religious world Professor Seeley does not regard as finalities. Under severe critical examination, they diminish and are found to have no justification in the truth of things. The work is one of the most composing and harmonizing that has appeared in this age. That the writer deals with the most radical problems of religious thought is shown in the titles of his chapters. In Part I the subjects treated are: (1) "God in Nature," (2) "The Abuse of the Word Atheism," (3) The words "Theology and Religion," (4) "The Three Kinds of Religion," (5) "Natural Religion in Practice," while in Part II the questions discussed are: (1) "Religion and the World," (2) "Religion and Culture," (3) "Natural Christianity," (4) "Natural Religion and the State," (5) "Natural Religion and the Church."

Holding this book to be of unusual importance, we are desirous of conveying to our readers a fuller account of it than we can prepare, or are in the habit of allowing in these pages, and we therefore reprint the review of it which appeared in the London "Athenæum" of July 29th:

If it be the function of genius to interpret the age to itself, this is a work of genius. It gives articulate expression to the higher strivings of the time. It puts plainly the problem of these latter days, and so far contributes to its solution; a positive solution it scarcely claims to supply. No such important contribution to the question of the time has been published in England since the appearance, in 1866, of "Ecce Homo." That the same man should have written both books, that none but himself can be his parallel, argues a unique order of mind. He is a teacher whose words it is well to listen to. His words are wise but sad; it has not been given him to fire them with faith, but only to light them with reason. His readers may at least thank him for the intellectual illumination, if they can not owe him gratitude for any added fervor.

The object of this book, one might say with logical precision, is to extend the connotation of the term "religion." It groups together all the great idealisms—art, science, culture—and claims that these are natural religion. Thus, according to this author, everything that takes us beyond and above our selfish aims is religion. The opposition between science and theology becomes vain and of no effect: both are forms of religion. The indifference of art for the conventions is but another form of the struggle against worldliness, and here again art and religion join hands. "Wer Wissenschaft und Kunst besitzt," said Goethe, and our author repeats the saying with approval, "hat auch Religion." Professor Huxley and Mr. Burne Jones will be somewhat surprised to find themselves regarded as great lights in the religious world. The old triad of ideals—the good, the true, and the beautiful—are classed by this observer under the one genus of religion.

Turning to the practical side of the book, we have the demand that the Church should learn the error of her ways in not recognizing her two companions in the struggle against the lower life, and should renounce the parts of her doctrine that conflict with their ideals. The idea of development must be applied to religion as to everything else, and the conception of prophecy be revived in the modern form of a philosophy of history. Let the cultured classes teach culture, which is religion, to the lower classes, who will otherwise lapse into Nihilism; and let the cultured nations of Christendom spread the light of religion till one great bond of civilization span the earth. Above all, if we wish to master the art of life, let us study the experiments that have been made by time in the field of history, and learn the lessons of "philosophy teaching by example."

Such, in main outline, are the theorems and problems of this brilliant book. The boldness of the *eirenicon* can not but strike every reader; but the age is bold in these matters, and this quality is only another mark of the timeliness of the book. In looking at its practicability, however, a critic has to remember that, while it takes two parties to make a quarrel, it also requires two to patch one up. Our author is wanting in one of the qualities of the peace-maker that are almost necessary for the due performance of his office: he lacks sympathy with one of the sides. He is entirely on the side opposed

to the angels, and assumes too confidently that supernatural religion is spiritually defunct, and its advocates ready to own their inefficiency. He is candid and clear-sighted, and sees distinctly that what he calls religion will be called in turn pantheism and paganism by "religious" people. But he trusts too readily that they will be convinced that, in using these names, they are miscalling persons of practically the same creed as themselves. He greatly underrates, one can not help thinking, the power that such conceptions as miracles, and heaven and hell, exert upon minds that have once firmly grasped them. At times this miscalculation leads him to adopt a tone toward the adherents of supernatural religion which is, to say the least of it, by no means conciliatory. Take, for instance, the following sentence:

"The Eternal and the Infinite and the All-embracing has been represented as the head of the clerical interest, as a sort of clergyman, as a sort of schoolmaster, as a sort of philanthropist."

The reminiscence of Mr. Matthew Arnold might remind our author that Mr. Arnold has scarcely reconciled Dissent, however he may have undermined it. In short, our author appears to agree with Goethe, when he cynically concludes the above-quoted epigram:

"Wer Wissenchaft und Kunst nicht besitzt
Der habe Religion."

Further, our author is scarcely so successful in showing the fundamental identity of art and religion as of science and religion. When touching on the latter point he draws some instructive and novel analogies between the creed of science and the faith of the Old Testament:

"I say that man believes in a God who feels himself in the presence of a Power which is not himself, and is immeasurably above himself; a Power in the contemplation of which he is absorbed, in the knowledge of which he finds safety and happiness."

"But now, either under the name of God, or under that of Nature, or under that of Science, or under that of Law, the conception works freshly and powerfully in a multitude of minds. It is an idea, indeed, that causes much unhappiness, much depression. Men now reason with God as Job did, or feel crushed before him as Moses, or wrestle with him as Jacob, or blaspheme him; they do not so easily attain the Christian hope."

"We have spoken of science as replacing miracle; prophecy it does not so much replace as restore. As it grasps human affairs with more confidence, it begins to unravel the past, and with the past the future. It shows the significance of each new social or political phase as the Hebrew prophets studied to do."

These quotations may serve to illustrate the author's main contentions as to the relation of science and religion. But it is more difficult to explain his views as to the connection of the artistic and religious ideals. He points out the great influence of the poet on the higher life of the time, reviving Mr. Arnold's "criticism of life" view; and he recognizes the ideal tendencies of the Antinomianism that is generally associated with artistic impulses. But he almost invariably regards art as solely dealing with beautiful objects of sight, and thus bringing it into contact with the scientific observation of nature. We have throughout observed not one word devoted to music, yet there are thousands nowadays with whom the cultus of rhythmic and harmonic sounds has usurped the place of almost all other worship, and a work on natural religion should have taken notice of their case. And on art in general, barring a few excellent pages on Goethe and Wordsworth, little is said that justifies the position given her alongside of science and religion. That position may be deserved; but the arguments brought forward in this book do not show adequate appreciation of the artistic mind.

Apart from this lack of sympathy with the orthodox schools of religious opinion, and an inadequate estimate of the artistic ideal, it is possible to find fault with other lines of the argument. There is, perhaps, a certain amount of professional exaggeration in the estimate formed of the historian's office. It is, to say the least, paradoxical to assert, "It is not exclusively, but only *par excellence*, that religion is directed toward God." It is obscuring a fundamental distinction to include, as our author often does, humanity in nature. The argument from Mohammedanism, that there may be a religion without miracles (p. 192), may be turned another way, when we reflect how inevitably the earliest traditions introduced miraculous events into the life of the Prophet. And interesting as is the attempt to widen the meaning of religion, it too often results in mere paradox, and manages only to evade difficulties by denying that they exist, Still the aim of the author, which is to point out the large amount of agreement among conflicting parties, is perfectly legitimate, and permits a certain exaggeration in looking only at common qualities, and neglecting divergencies.

Turning to the more pleasant and more profitable task of pointing out the many novel ideas and brilliant thoughts contained in this book, one has first to notice the power of acute social diagnosis that is throughout displayed. Take, for instance, the following *résumé* of the scientific temper:

"Instead of that painful conflict with temptation which moralists describe, there may be an almost unbroken peace arising from the absence of temptation; instead of the gradual formation of virtuous habits, there may be the gradual disuse of all habits except the habit of thought and study; there may be perpetual self-absorption, without what is commonly called selfishness, total disregard of other people, together with an unceasing labor for the human race. A life, in short, like that of the vestal, 'the world forgetting, by the world forgot,' yet without any love or heavenly communion."

Or, again, take the few but weighty words dealing with Nihilism; or the account of the

epidemic character of crime; or the remarks on the rise of self-distrust consequent on the decline of authority; or the view that the modern schoolmaster is a kind of professional parent. And joined to this power of observation is found the power of expressing its results in short, pithy phrases or sentences that stick in the memory. "Life is interesting if not happy" is a whole answer to Mr. Mallock. "Is life but a livelihood?" is a home-thrust at a certain school of politicians. "Worship is habitual admiration" is not likely to be bettered for some time as a working definition.

Nowadays one is not allowed to call a book brilliant unless it says some witty and therefore spiteful things. Even these are not wanting in the pages of "Natural Religion." Let us cull a few that display this quality:

"If you want to see the true white-heat of controversial passion—if you want to see men fling away the very thought of reconciliation, and close in internecine conflict, you should look at controversialists who *do not differ at all*, but who have adopted different words to express the same opinion."

"What should we think, then, if its name and its glories formed the staple of our religious worship, if our church-goers sang, 'Oh, pray for the peace of England—they shall prosper that love thee'?"

"'Erudition' and 'philosophy' are terms of contempt in their mouths. They denounce the former as a busy idleness, and the latter as a sham wisdom, consisting mainly of empty words, and offering solutions either imaginary or unintelligible of problems which are either imaginary or unintelligible themselves."

But of far more importance than these isolated instances of acuteness of thought or phrase are the many new positions taken up in this book. The distinction between theology and religion has never been brought so clearly into connection with the difference between scientific and imaginative knowledge. The three different phases of atheism—by which term is meant by this author want of adaptation to the environment—are excellently discriminated.

It may cause some surprise, but can not fail to cause as much enlightenment, to find our author, most modern of the moderns as he is, advocating the closest possible union between Church and state, and defending his position by all the wealth of his historical knowledge. But has ever the modern temper been hit off more exactly than in the following passage?—

"Another maxim has to be learned in time, that some things are impossible, and to master this is to enter upon the manhood of the higher life. But it ought not to be mastered as a mere depressing negation, but rather as a new religion. The law that is independent of us, and that conditions all our activity, is not to be reluctantly acknowledged, but studied with absorbing delight and awe. At the moment when our own self-consciousness is liveliest, when our own beliefs, hopes, and purposes are most precious to us, we are to acknowledge that the universe is greater than ourselves, and that our wills are weak compared with the law that governs it, and our purposes futile except so far as they are in agreement with that law."

But enough. We have given the main argument of the book, and selected some of its details for discussion or for admiration. It remains to discuss its probable effect on the two parties between whom, in a measure, it attempts to effect a reconciliation. It has already been pointed out that the religious world will regard its religion as having been misunderstood, and not sympathized with; and this complaint will be just. It is natural, at this point, to compare the somewhat similar attempts of Mr. Matthew Arnold in this direction; and it must be owned that, with regard to knowledge of and sympathy with orthodox belief, the whilom Oxford professor is the superior of his Cambridge rival, if we may venture so to term the author of "Ecce Homo." Mr. Matthew Arnold was bent on battling with religious Philistinism, and did not disdain to deal it some heavy and rather unfair blows, chiefly by way of irony. Our author, on the contrary, cares more to expound the position of *nous autres*, and has, for the first time, given an adequate exposition of the creed of culture. "Religion," he says, "has been revived under the artificial name of culture"; and, again, "The momentary evanescence of the Church in modern life is only caused by the decay of one sort of Church coinciding in time with the infancy of another." In thus boldly pointing out that the spiritual currents now flow in other channels than those that are technically called religious, the book says what many have been feeling. It must necessarily give courage to the Antinomians, and give, for the first time, a true sense of their position to the followers of ancient lines of thought. That the followers of culture will consent to call their ideal by the name of religion, and that the believers of religion in its old sense will grant that name, full of the most sacred associations, to the pursuit of truth and of beauty, are very doubtful propositions. So far, therefore, as our author seriously aims at these innovations his efforts appear doomed to failure. No *eirenicon* can be effected between two opposing schools by inducing them to adopt the same name on their banners. It is by bringing into full consciousness the thoughts and feelings of modern men that this book will exercise its chief influence. It will enable the adherents of the old and of the new faith to know for what the strife is being carried on. And it shows how fast and far the world has been drifting since 1866 to reflect that this book takes the place of an exposition of "Christ's theology" promised in the preface of "Ecce Homo." But the second or "practical" part of the book is not practical in any sense that leads to action. It merely shows that the natural religion which is his theme is really in action among us in influencing men's lives. It may set men thinking, it can not lead them to act. Meanwhile, let us close this notice of a book which we assume will be read by most thinking Englishmen with a

final quotation, which shows at once the power and the weakness of the writer, his clear vision and his depressing tone:

"For Art and Science are not of the world, though the world may corrupt them; they have the nature of religion. When, therefore, we see them shaking off the fetters of the reigning religion, we may be anxious, but we are not to call this an outbreak of secularity; it is the appearance of new forms of religion, which, if they threaten orthodoxy, threaten secularity quite as much. Now, secularity is the English vice, and we may rejoice to see it attacked. It ought to be the beginning of a new life for England that the heavy materialism which has so long weighed upon her is shaken at last. We have been, perhaps, little aware of it, as one is usually little aware of the atmosphere one has long breathed. We have been aware only of an energetic industrialism. We have been proud of our national 'self-help,' of our industry, and solvency, and have taken as but the due reward of these virtues our good fortune in politics and colonization. We have even framed for ourselves a sort of Deuteronomic religion which is a great comfort to us; it teaches that because we are honest and peaceable and industrious, therefore our Jehovah gives us wealth in abundance, and our exports and imports swell, and our debt diminishes, and our emigrants people half the globe."

Ernestine. A Novel. By Wilhelmine von Hillern, author of "The Hour will Come," etc. From the German by S. Baring-Gould. In two vols. New York: William S. Gottsberger. Pp. 711. Price, $1.50.

Ernestine first appears before the reader as a little, much-abused, ill-tempered girl, about ten years old, who was neglected in everything except her schooling. When grown up, she thus describes herself: "From earliest childhood—at a time when most are rocked in the arms of love—are laid to sleep in the lap of love—I was trampled on, kicked about, almost tortured to death, because I was a girl. Every anguish-cry of my breast, every thought of my soul, every feeling of my young heart, was gathered into this one question, 'Why, why must I expiate what is no fault of mine—that I am not a boy?' And, in every wound that was dealt me, the seed of revenge was strewn—the seed of revenge for my own wrongs and those of my sex—the seed of ambition to do all that can be achieved by that sex whose superiority was so insultingly, so brutally paraded before me. It ripened quickly in the glow of indignation I felt at the injustice my sex is forced to endure, the difficulties which were opposed to its endeavors to rise above vulgar routine. It grew with me; it became mighty; it ramified through my whole mental life, like the veins and nerves of my body." When her application to attend the lectures and to be admitted to the dissecting-tables of the university was rejected, she declared to the committee that "the great struggle for the emancipation of woman can only be fought out to a definite conclusion on the comparative anatomy of the brain. . . . If, in some less scrupulous university, I be admitted to the dissecting-tables, and allowed the necessary anatomical and physiological studies, my time and energies will be given up to the solution of this question." But unceasing study undermined her health, and after a painful and involved experience the anti-social feelings that had been fostered by her abnormal childhood and youth gave way, and she became an affectionate wife and mother.

As a novel the book is engrossing and satisfactory, and, as a German contribution to the discussion of "The woman question," it is very interesting. The implication would seem to be that the usual course of domestic and social life in Germany does not favor the discontent of woman with her woman's destiny. It is under most exceptional circumstances that Ernestine is developed, and whenever she comes in contact with German society she is rebuked on all sides. It is the impression produced upon a very high-minded and accomplished young *savant* by her wonderful spiritual beauty, her purity of purpose, and earnestness of character that leads to her disenchantment. She is, however, allowed a little more time for a radical change of character than is accorded in most novels. But, as the author is dealing with people who are deeply versed in medical science and all modern research, this much was not unreasonably to be expected.

If Miss Von Hillern had been writing of woman's position in a novel of American life, her problem would have been different. She would find her discontented, ambitious, over-intellectual girls everywhere; which, of course, implies a state of society that fosters their production. She would find them both welcomed and influential in society, and, if not considered the most eligible can-

didates for matrimony, it matters very little to them. There is scope enough in this country for independent careers, and many of our "smart" girls fancy that on the whole an independent career is more desirable than marriage with its inevitable subordination of the woman. Fairly to present this subject to the American mind requires a careful study of the influences at home, at school, and on all sides, that are acting upon the minds of our girls and modifying their tastes and feelings, and, also, of those deeper biological characteristics which must remain essentially the same from age to age. It must be shown that from the beginning woman has been, and to the end she must remain, an emotional rather than an intellectual being—that much transient mischief and no good can come from a disturbance of this normal balance of thought and feeling in the mind of woman. It is high time that somebody in this country, be it novelist or essayist, should bring forward this view of the subject of "woman's rights." For the assumption of the identity of the minds of men and women is wide-spread. Hence the demand for identical education, and the opening to women of all our halls of learning. The fact that the emotional nature of woman has precedence at the present time is regarded as a principal reason for the educational movement. It is no education, or wrong education, we are told, that has deformed her true nature, and that her mind may assume right proportions she is called upon to cultivate intellect as a means of suppressing emotion.

This is precisely what Miss Von Hillern's heroine had striven all her life to do, and she fancied at one time that she had gained the victory for intellect. But all her striving comes to nothing. At last we find her exclaiming: "What are learning and fame, what the pride of position, compared with the happiness of this moment? Away with them all! my choice is made, Johannes," and she sank upon his breast. And this, too, when the last words said to her by her lover were these: "True humility will teach you to yield your fate unquestioningly to the man who gives his life to you. Go from me and you may be great, but you can not be womanly, and what is such greatness attained at the cost of a heart? Give up the false pride that would seek fame beyond the bounds of a woman's sphere, and confess that there is nothing greater that you can do than to enrich and bless the man who loves you." But, in Germany, where all the forces of society conspired to Ernestine's defeat, our authoress had no difficult task in reaching this result. It is not so easy to imagine a discipline that would bring one of our learned girls to this humble pass.

The subject is one of profound importance, and we commend the work to thoughtful readers, as well as to those who read novels only for entertainment.

Practical Microscopy. By George E. Davis, F. R. M. S., F. I. C., F. C. S., etc. Illustrated with 258 Woodcuts and a Colored Frontispiece. London: David Bogue. Pp. 335.

The neatly printed and beautifully illustrated book before us is somewhat similar to Quekett's "Practical Treatise on the Use of the Microscope," but is a smaller and less costly book, and one that brings the subject down to the present time. The various parts of a microscope are briefly described from a practical stand point, no mathematical calculations being introduced, nor is any attempt made to explain the *theory* of the microscope, further than it is of practical value. Although intended for students and even beginners, some singular omissions occur, such as explanations of the oft-used term "air-angle," or of the principle of "immersion lenses." The various accessories of the microscope are fully illustrated and described. There is a chapter on the collection of objects, another on micro-dissections, also on section-cutting and microscopic measurements. One of the most valuable features of the book is its full and accurate directions for making photo-micrographs, with cuts of apparatus. Recipes are given for the developing and fixing solutions, the printing and toning baths, and other parts of the photographic operations are minutely described. The chapter on the polarizing microscope is more full than we usually meet with in books of this character. The micro-spectroscope, the most modern of all the adaptations of the microscope, here receives the

attention that so remarkable an instrument deserves. The staining and injecting of objects are as fully treated of as the size of the book would permit, and a colored frontispiece is introduced to show the effect of double-staining on wood-sections.

The author exhibits commendable fairness in his treatment of American microscopists, and of instruments made on this side of the water, especially the wide-angled objectives of Spencer, of Geneva, and Tolles, of Boston. He says: "It is only recently that American objectives of the widest aperture have found their way into the author's hands. Their definition is marvelous." Medium angles have been advised for students' use, because they can be employed without much previous knowledge or difficulty; but for all purposes of scientific investigation wide apertures give more satisfactory results.

Many of the illustrations have been photographed by the author from nature and then cut in wood. Some of these are very fine, as, for example, the sting and poison-bag of the bee and wasp, the digestive apparatus of the water-beetle and of the blow-fly, and various other natural objects.

The rapid strides that have recently been made in the manufacture of cheap and very good working microscopes have created a demand for works of this character, and Mr. Davis's book supplies a real want.

Guide to the Flora of Washington and Vicinity. By Lester F. Ward, A. M. Washington: Government Printing-Office. 1881. Pp. 264.

This recent publication of the Smithsonian Institution contains the scientific and common names of 1,384 plants found in the vicinity of the national capital, together with their time of flowering, and in many cases the localities where they may be sought for. Appended are a check-list and a map of the region for fifteen or twenty miles around the city of Washington. The labor of preparing a "flora" of even a limited space of country is much greater than might be supposed, and in the present case many able and active botanists have co-operated with the author, as well as many energetic amateurs. The appearance of this work recalls to mind a remark of the late Dr. John Torrey, that in his younger days he attempted to prepare a flora of the City Hall Park, New York. At that time there was neither post-office nor court-house there. Even in that small space he met with so many and such a rapidly increasing number of varieties and species that he was compelled to abandon the project. From its cosmopolitan nature New York naturally receives fresh additions to her flora annually from every quarter of the globe. Even in Washington there has been a considerable change in the flora since the "Prodromus" appeared half a century ago. Of the 860 distinct plants enumerated therein, the author has succeeded in identifying 708, while nearly as many more have been added. Although the primary aim of the author was to furnish a guide to botanists in exploring the locality, it will serve as an aid to beginners in practical botany elsewhere. An appendix is added, especially addressed to the latter class, and containing among other things suggestions regarding identification of plants, collection of plants, preservation of plants, making an herbarium, care of duplicates, exchanging specimens, etc. On the first of these points the author remarks that "a young botanist's struggles with botanical keys can only be sympathized with; they can scarcely be aided by any general directions, and there is no more effectual drill than the persevering effort to identify, by the aid of a key, a plant to which he has no clew. It should be the ambition of every such beginner to analyze in this manner all the plants of his local flora." The less help he receives the better, and, the more ignorant the beginner is at the outset, the better will be his ultimate acquaintance with botany if he perseveres in the work. In regard to localities the writer very appropriately remarks that "in many respects the botanist looks at the world from a point of view precisely the reverse of that of other people. Rich fields of corn are to him waste lands; cities are his abhorrence, and great open areas under high cultivation he calls 'poor country'; while on the other hand the impenetrable forest delights his gaze, the rocky cliff charms him, thin-soiled barrens, boggy fens, and irreclaimable swamps and morasses are for him the finest land in the State. He

takes no delight in the 'march of civilization,' the axe and the plow are to him symbols of barbarism, and the reclaiming of waste lands and opening up of his favorite haunts to cultivation he instinctively denounces as acts of vandalism." Yet we may add, the botanist himself is no vandal, but his humble labors do contribute to the onward march of civilization. The humblest flower or coarsest weed may contain lessons of wisdom the most profound, and botany is particularly adapted to combine science and culture.

We can not close our brief notice without a mention of his defense of the herbarium as an instrument of scientific culture. It is a collection of natural objects, scientifically classified and ever present for inspection; an herbarium is a library to be consulted, studied, and read. It is a library filled with volumes written by Nature, and which those who have learned the language of Nature can read and enjoy with a satisfaction as much keener than anything that man-made books can give as it is nearer to the source of all truth.

Reminiscences chiefly of Oriel College and the Oxford Movement. By Rev. T. Mozely, M. A., formerly Fellow of Oriel. In 2 vols. Boston: Houghton, Mifflin & Co. Pp. 900. Price, $3.

These volumes belong to a popular class of works, and have attracted a good deal of attention as being quite unique in their line. They are gossipy, sketchy, spicy, and readable, and, although dealing with characters that figured and events that occurred half a century ago, and across the ocean, they will be read with interest and by many with avidity in this country. The interest in Oxford University, as a great seat of learning, is not confined to England, and everybody has heard of the Oxford movement, an ecclesiastical fermentation in the university which greatly disturbed the English Church, and involved the secession of many of her theologians to the Church of Rome. The work is thus characterized by a writer in the "Quarterly Review":

"It is, in great measure, a gallery of portraits, vividly and even brilliantly sketched, of the remarkable body of men who were connected with Oriel College for about half a century of its most famous period. The book is a succession of short chapters, each about the length of a leading article, most of them depicting the appearance, the habits, the capacities, and characters of a number of men who, for two generations, have played a leading part in English thought and life. Nothing but intimate daily association could have enabled even a genius like that of Mr. Mozely to hit them off with such distinctness and accuracy. But he and they were, for the most part, fellows or gentlemen commoners, or undergraduates of the same college; even if of different colleges, they lived in the same university, under similar conditions. He saw them going out and coming in; he dined with them; spent the evenings with them; worked side by side with them; managed business with them for years. All their characteristic and tell-tale traits fell under his daily observation, and he came to know them as well as, or perhaps better than, himself. If we had no other occasion for welcoming this book, we could not but rejoice to have such a vivid picture of a kind of life which has played so large a part in English society, drawn at the very time and in the very college where, perhaps, it reached its culmination. Mr. Mozely depicts it, not only with very rare powers of observation and of description, but with the keen appreciation of sympathy and of close attachment. As we read his pages we live in the Oxford and the Oriel of his day; we follow all its social politics, slight as they may seem, with the interest of real human life; we discern how all the little details developed characters and determined careers, and see before us, in scores of instances, that constant action and reaction of individuals and circumstances out of which the drama of life is developed."

In a book of so many details, and relating mainly to distant personal experiences, we might naturally expect a good percentage of error, and our pages this month bear testimony to Mr. Mozely's fallibility in this respect. He was a pupil in Derby of Mr. George Spencer, father of Herbert Spencer, and some of his reminiscences of his early teacher have proved so misleading as to require particular correction.

The Students' Guide in Quantitative Analysis. Intended as an Aid to the Study of Fresenius's System. By H. Carrington Bolton, Ph. D., Professor of Chemistry in Trinity College, Hartford, Connecticut. Illustrated. New York: John Wiley & Sons. Pp. 127. Price, $1.50.

The little book before us is intended as a guide for the student at his desk rather than as a text-book for study; it may be called a *key* to the comprehensive work of the distinguished Fresenius. In the latter the *science* of quantitative analysis is exhaustively taught, but the young chemist is too often bewildered by the wealth of material therein presented. He can not see the forest for the trees. Professor Bolton has cut a path for him through the wilderness; he has selected those points which it is important for the student to see, and placed them prominently before him. This book seeks to teach the *art* of quantitative analysis, without, however, entirely neglecting the science that lies at its base. The author presents a course of thirty-six typical analyses, arranged progressively from the simplest to the most complex, in the order that they are taken up in chemical laboratories generally, in the Columbia School of Mines particularly. The first analysis is that of barium chloride; each step in the operation is given in detail, and when the student has faithfully repeated these operations he has learned how to estimate barium, chlorine, and water of crystallization, in almost any salt. Next follows magnesium sulphate, in which he determines magnesium, sulphuric acid, and water. A few other salts follow, and, when the student has become familiar with chemical operations, natural and technical products are given, such as coal, ores, alloys, and slag, closing with water, sugar, milk, and petroleum. The whole course of quantitative analysis, both volumetric and gravimetric, is herein described, and the student who has made the analyse swith care will certainly have attained a considerable skill in manipulation, and can scarcely fail of obtaining an insight into the underlying principles which would enable him to devise methods adapted to other cases not given in the book. To aid in this, every step in each analysis contains a reference to the chapter and section in "Fresenius," where the operation is described, or to other authorities, when, as in a few cases, others were made use of. For this reason we have called it a "key," or guide, to the study of Fresenius. The book is intended as an aid to the teachers of quantitative analysis, to spare them the necessity of explaining to each student all the details of each analysis, which, in our overcrowded laboratories, the teacher has no time to do. It is equally suitable for "self-instruction," and by its aid any young person, with a fair knowledge of general chemistry, can, by himself, go through a course of analysis, lasting say two years, that would fit him for a position in a commercial or technical laboratory. The work is similar to Woehler's "Mineral Analysis," but fuller in detail, newer in methods, and in every way better suited to the wants of the American student. To compare things in totally different spheres, we would say that it resembles the "South Kensington Cook-Book," and this is no small praise.

Astronomy for Schools and General Readers. By Isaac Sharpless, Professor of Mathematics and Astronomy, Haverford College, and Professor G. M. Phillips, Principal of State Normal School, Westchester, Pennsylvania. J. B. Lippincott & Co. Pp. 303. Price, $1.25.

This is a very judiciously prepared school-book, neatly printed and elegantly illustrated. The explanations are clear, and the subject-matter of exposition well chosen for popular purposes. It opens with a sketch of the history of astronomy as part of an introduction, which is followed by a general view of the heavens and some considerations of the usefulness of astronomy. The solar system is then taken up in Part I, and the sidereal system in Part II, while Part III is devoted to the properties of light and astronomical instruments. There are no questions to the volume, but pains are taken to give the proper pronunciation of terms, and there are brief notices of the eminent men who have contributed to the progress of astronomy. No one book can combine all excellences, but this may be commended as well adapted for general school use.

PUBLICATIONS RECEIVED.

Atlantis: The Antediluvian World. By Ignatius Donnelly. Illustrated. New York: Harper & Brothers. Pp. 490. $2.00.

Astronomy for Schools and General Readers. By Isaac Sharpless and Professor G. M. Philips. Philadelphia: J. B. Lippincott & Co. Pp. 303. $1.25.

Cerebral Hyperæmia: Does it exist? By C. F. Buckley, B. A., M. D., formerly Superintendent of Haydock Lodge Asylum, England. New York: G. P. Putnam's Sons. Pp. 129.

A Guide to Collodio-Etching. By Benjamin Hartley. Illustrated by the Author. New York: The Industrial Publication Company. Pp. 48, with Seven Plates.

Social Equality. A Short Study in a Missing Science. By William Hurrell Mallock, author of "Is Life worth Living?" New York: G. P. Putnam's Sons. Pp. 212. $1.00.

A Dictionary of the Popular Names of Economic Plants. By John Smith, A. L. S., author of "Historia Filicum," "History of Bible Plants," etc. London: Macmillan & Co. Pp. 457. $3.50.

Light. A Course of Experimental Optics, chiefly with the Lantern. By Lewis Wright. With Illustrations. London: Macmillan & Co. Pp. 366. $2.

Memoir of Daniel Macmillan. By Thomas Hughes, Q. C., author of "Tom Brown's Schooldays at Rugby." London: Macmillan & Co. Pp. 308. $1.50.

Strength of Wrought-Iron Bridge Members. By S. W. Robinson, C. E. New York: D. Van Nostrand. Pp. 175. 50 cents.

Railroad Economics. By S. W. Robinson, C. E. New York: D. Van Nostrand. Pp. 131. 50 cents.

First Annual Report of the Board of Health of Detroit. July, 1882. Detroit: Post & Tribune Co., Printers. Pp. 270.

The New Botany. A Lecture on the Best Method of teaching the Science. By W. J. Beal, M. Sc., Ph. D. Second edition, revised. Philadelphia: C. H. Marot. Pp. 16. 25 cents.

Houghton Farm: Experiments with Indian Corn. 1880-1881. By Manley Miles, Director of Experiments, with a Summary of the Experiments with Wheat for Forty Years at Rothamsted. By J. B. Lawes, Bart., LL. D., F. R. S. Cambridge: Riverside Press. Pp. 75.

Hand-Book of the St. Nicholas Agassiz Association. By Harlan M. Ballard, Principal of Lenox Academy. Pittsfield, Massachusetts: Axtell & Pomeroy, Printers. Pp. v-85.

Proceedings of the Department of Superintendence of the National Education Association at its Meeting in Washington, March 21-23, 1882. Washington: Government Printing-Office. Pp. 112.

The Comparative Action of Sulphate of Daturia and of Sulphate of Hyoscyamia upon the Iris and Ciliary Muscles. By Charles A. Oliver, M. D., of Philadelphia. Pp. 7.

Map of Alaska and Adjoining Regions. Compiled by Ivan Petroff, Special Agent, Tenth Census. Washington. Large Sheet.

Report of T. B. Ferguson, a Commissioner of Fisheries of Maryland. January, 1881. Hagerstown, Maryland: Bell & Co., Printers. Pp. cxiv, 152, and 6, with Plates.

Proceedings of the Davenport Academy of Natural Sciences. Volume III. Part II. Davenport, Iowa: Published by the Academy. Pp. 192, with Five Plates.

A Synonymical Catalogue of the Described Tortricidæ of North America, north of Mexico. By C. H. Fernald, A. M., Professor of Natural History in the Maine State College. Pp. 72.

The Hyperbolic Curve and the Law of Progression of Rotating Bodies. Boston: A. Williams & Co. Pp. 16.

Annual Report upon the Surveys of Northern and Northwestern Lakes, in charge of Major C. B. Comstock. Washington: Government Printing-Office. Pp. 24.

Arak-el-Emir. A Quarterly, devoted to the Expression of Clear Investigative Thought, conducted by J. C. Lane. New York: Quarterly Publishing Company, 21 Park Place. Pp. 82. 75 cents. Subscription, $3 per annum.

Elements of Universology. By Stephen Pearl Andrews. New York: S. P. Lathrop & Co. Pp. 48. 15 cents.

Ideological Etymology. A New Method on the Study of Words. By Stephen Pearl Andrews. New York: S. P. Lathrop & Co. Pp. 32. 15 cents.

Three Reports on Nomenclature and Terminology. By W. H. Atkinson. Pp. 6, 12, and 6. 5 cents each.

POPULAR MISCELLANY.

The American Association.—The meeting of the American Association for the Advancement of Science, at Montreal, which closed August 30th, was, in every respect, one of the most successful meetings in the history of the society. The attendance—nine hundred and fifty members—was but little short of that registered at Boston two years ago, and constituted it one of the large meetings. Three hundred and twenty-five new members were elected, and more than two hundred and fifty papers were accepted. The meeting was opened on the 23d of August, with a brief address by the incoming President, Dr. Dawson, of Montreal, who spoke of his (a Canadian's) election to the presidency as significant of the society's extension over the continent, and its disregard of national boundary-lines. Dr. T. Sterry Hunt, who followed the president as the especial representative of the city of Montreal, also spoke of the expansion of the society, and expressed the hope that it might yet meet in the city of Mexico, as the French had already carried their "war of science" into Africa, at Algiers. The nine sections into which the Association is now divided were severally opened with addresses by their respective presidents. Professor Bolton, in the Chemical Section, spoke on "Chemical Literature"; Professor Harkness, in the Mathematical and Astronomical Section, on the transit of Venus. Professor Brush, the retiring President of the Association, gave as his official address the compre-

hensive review which we publish in the present number of "The Popular Science Monthly," of the "Progress of American Mineralogy." Dr. Asa Gray gave an address on the "History of the Study of the North American Flora," and expressed the hope that the work of examination and classification might be completed in his lifetime, if it could not all be guided by his hand. The other papers were too numerous to be even catalogued here. We mention only a few, which seem to be of general importance or interest. They are those of Professor Mason, unfolding a scheme of anthropology; of Dr. John Rae, of London, on "Arctic Explorations and Ethnology"; of Commander Bartlett, on "The Gulf Stream"; of Mr. Franklin B. Hough, on "Plantations of the Eucalyptus"; of the Rev. Dr. Houghton, of Dublin, embodying a new theory of the evolution of the planets; of Professor Cook, of New Jersey, on "Evidences of Coast Depression"; of H. Carvill Lewis, on "The Great Terminal Moraine across Pennsylvania"; of Professor Newberry, on "The History of Plant-Life in America"; of the Hon. Horatio Hale, of Clinton, Ontario, on "Indian Migrations as evidenced by their Language"; and of Mrs. Erminie Smith and Miss Alice C. Fletcher, on topics relating to Indian ethnology. Excursions were made to Quebec, Ottawa, and other places. Several visitors of distinction were present from abroad. Among them, besides those already named in connection with their papers, were Professor W. B. Carpenter, of London, who read a technical paper in the Microscopical Section; Dr. Valdemar Kovalevski, of Moscow; Dr. Koenig, of Paris; Mr. Fitzgerald, of Dublin; and D. Szabo, of Buda-Pesth, Hungary, who had a paper in the Chemical Section. A good financial exhibit was made, with the announcement of generous special gifts. A memorial to Professor Rogers was determined upon. The Association decided to hold its meeting for 1883 at Minneapolis, Minnesota. The following officers were chosen: President, Professor C. A. Young, of Princeton; vice-presidents of sections: Mathematics and Astronomy, W. A. Rogers, of Cambridge; Physics, H. A. Rowland, of Baltimore; Chemistry, E. W. Morley, of Cleveland; Mechanical Science, De Valson Wood, of Hoboken; Geology and Geography, C. H. Hitchcock, of Hanover; Biology, W. J. Beale, of Lansing; Histology and Microscopy, J. D. Cox, of Cincinnati; Anthropology, O. T. Mason, of Washington; Economical Science and Statistics, F. B. Hough, of Lowville. The purpose of the British Association to hold its meeting for 1884 in Montreal was announced.

Scientific Forestry.—There is no mystery in the scientific cultivation of forests, so far as concerns the tillage of the crop. All that is needed is to observe the action of nature in the forest, and follow it, or utilize it advantageously, when that can be done. The object of the cultivation should be to obtain the utmost possible advantage from the soil by keeping it always covered with a growth of trees; and, when the trees arrive at maturity, to remove them in such a manner that the smallest possible interruption may be caused to the productive work of nature. When the time has come for the removal of the timber, the ground should on no account be anywhere all cleared of trees at once; but a commencement should be made by felling a tree here and there, and so breaking the thick cover of the forest as to allow sufficient light and air to reach the ground, and cause the seed which has fallen to germinate. In this way about one fifth of the mature trees should be removed every five or six years, never by making large gaps in the cover, but taking a tree here and there, and always leaving the finest and most vigorous trees till the last, so that in about thirty years the whole of the old trees will be cleared off, and a new forest established in their place. Thus the seeding of the wood will be effected by the agency of the finest trees, which will be themselves all the while increasing in bulk, and the productive power of the soil will be utilized to the fullest possible amount. It is not only in the removal of the timber and the reproduction of the forest that we ought to study the action of nature, but it is equally necessary that we should do so in the felling for improving the growing crop, or, as it is commonly called, the thinnings. The competition between trees after they reach their full height, at half their full age, is for space to spread their heads;

and from this time, till they arrive at maturity, they go on always augmenting the diameter of their stems, but at the same time decreasing in number. It is calculated that, if sixteen hundred trees of four inches in diameter can stand and thrive on an acre of ground, there will not be more than four hundred of them when the trees have grown to eight inches, two hundred when they have reached twelve inches, and between one hundred and one hundred and forty when they have attained sixteen inches in diameter. Little is to be done in the earlier stages of a forest's growth except to keep the heads of the most valuable species from being overtopped by those which stand near them: and this can be done best, not by removing the others, but by cutting off or breaking the tops; for it is desirable at this stage, for the sake of the natural pruning, to have the trees growing as thickly together as possible. At a later stage, thinnings can be judiciously arranged so as to pass through the entire forest at intervals of from ten to fifteen years, enabling the whole area to be operated on in turn. In executing these, the most difficult of all forest operations, it will be well to remember that the object is to give room to the heads of the trees, and not to their stems; for the stems will never be too close together as long as the heads have room properly to develop themselves. The favoring of the most promising trees, and the removal of the weaker ones, together with the preservation of continuous shade to the surface of the ground, while all the trees have sufficient room to grow, should be the particular ends aimed at.

A New Plan for Armored Vessels.—The Naval Committee of the United States House of Representatives has given favorable consideration to a new plan for building armored vessels which has been devised by a retired invalid engineer. The principal armorial application consists of a submerged "turtle-back," about four inches thick, and extending from side to side and from stem to stern of the vessel and below the water-line, so arranged that an enemy's shot from any direction can hit it only at a deflecting angle, so as to be thrown off rather than go through. The sides of the vessel above the turtle-back are filled in with cotton or cork, in which a breach made by the passage of a ball will be self-closed by the elastic action of the substance. They may, moreover, be shot to pieces without destroying the buoyant power of the ship. The guns are mounted upon heavy, impenetrable, centrally arranged, cylindrical armor, which extends to the bottom of the ship, and is there seated on an hydraulic cushion. The breech of the gun is also inclosed in an oval armor, so arranged as to deflect a ball, striking it from any point, in a harmless direction. The gun is operated by an hydraulic loading apparatus, which is worked by one gunner, and hydraulic buffers are provided to take up the recoil.

The Timber-Line of Mountains.—Mr. Henry Gannett, noticing, in "The American Journal of Science," Dr. Rothrock's statement that, as a whole, there is little or no increase in the altitude of the timber-line toward the equator in the Western hemisphere, south of the forty-first parallel of north latitude, observes that the height of the timber-line is purely a question of temperature, and that that is a function of the latitude, the elevation, and the mass, of the country in the neighborhood. A great mass of country, if raised to a considerable height above the sea, carries with it the isothermals. Therefore, in considering the height of the timber-line, "we must regard the mountain-ranges in connection with the plateaus on which they stand, their latitudes, heights, and masses, or what, in a measure, sums up these three, their temperatures, as it is by these that its height is determined." The actual elevation above sea-level of the timber-line in the Cordilleras of North America ranges from six or seven to twelve thousand feet. It is lowest in the Coast and Cascade Ranges of Washington Territory, and rises as we go southward through Oregon and California. On the high Sierras of Eastern-Central California, forests grow to 10,000 or 12,000 feet, while the ranges of Southern California do not reach the upper limits of forests Few of the ranges of Nevada reach the timber-line, which varies from the height of 9,000 feet in the northern to probably 11,000 feet in the southern part of the State. In Ari-

zona, probably none of the mountains reach the timber-line except the San Francisco group and the Sierra Blanca, where the line is at 11,000 and 12,000 feet. In New Mexico, the line averages about 12,000 feet above sea-level, and the higher annual temperature of the southern part of the Territory is fully compensated for by the greater altitude of the plateau in the northern part. In Colorado, the line rises from 11,000 feet in the northern to 12,000 feet in the southern part of the State; in Wyoming, from 10,000 to 11,000 feet in the Wind River and Teton Ranges, to about 11,000 feet in the Park Range; in Montana and Idaho, it ranges at from 9,000 to 10,000 feet, and in the Uintah and Wahsatch Ranges of Utah it is at about 11,000 feet. It is evident, if these considerations hold good, that the upper limit of timber must have approximately the same mean annual temperature everywhere. This temperature can not be measured directly for different places, but may be estimated by calculation by taking the mean temperature at some base in the neighborhood, and allowing a degree of fall for every three hundred feet of additional elevation. A calculation made on this basis for thirteen mountains, including Mounts Washington and Marcy, and several Western peaks, gives a mean of 30.4°, the extremes being 28° and 33°.

The Soil and Scarlatina.—Dr. Eklund, of Stockholm, Sweden, has for several years devoted much time to the pathology and etiology of scarlatina, and has reached conclusions of high practical importance in the light they throw upon the connection between bad drainage and other insanitary conditions and outbreaks of that disease without actual infection. He has constantly found a prodigious number of discoid bodies in the urine of persons suffering from scarlatina, and most positively asserts that he has also noticed those identical organisms in vast numbers in the soil and ground-water of the Isle of Skeppsholm; in mud from the trenches, dug for the water-mains; and among the greenish molds of the walls of the old barracks, where scarlatina was most rife. He furthermore alleges cases of scarlatina occurring in children after drinking milk mixed with the ground-water of the island, and one case which followed an immersion in one of these trenches, and the drying of the child's clothes in a small room. In still another case scarlatina broke out in a block immediately on the exposure of the ground-water by excavations around. These observations, however, and those of other persons who have found micrococci in the animal fluids in scarlatina, even if the organisms are observed to be invariably present, can not be held to prove that they are the cause of the disease till the fact has been directly verified by inoculation into a healthy body carefully isolated from all other sources of infection.

Lip-Teaching for the Deaf and Dumb.—Earl Granville, as President of the Association for the Oral Instruction of the Deaf and Dumb, had occasion recently, at a meeting in behalf of the system, to remark upon the satisfactory progress that had been made in lip-teaching, by which the deaf were placed in a position to converse with their fellow-creatures without the aid of signs. The number of pupils in the association's school had increased, and favorable reports had been received from the class of the School Board of London. Except where idiocy or mental incapacity existed, this method of teaching was applicable to all cases. Its advantages had been acknowledged in a remarkable degree at a conference lately held, where a consensus of opinion was expressed in its favor. In evidence of the great benefits the system conferred upon persons trained under it, Earl Granville mentioned that several former pupils of the school were present who were now earning their living in positions which they would hardly have obtained had they been educated by the system of signs. An examination was afterward had of pupils of the training college and school, in which they showed that they understood, by watching a speaker's lips, what was said to them, and could make intelligible replies to it.

Chaldean Astronomy.—The invention of astronomy is ascribed to the Chaldeans by some ancient writers. It is said that a certain Zoroaster, King of Bactriana, was the first who observed the stars, about 1700 B. C.; although, according to Porphyry, Cal-

listhenes found at Babylon and sent to Aristotle a series of observations going back to the earlier date of 1903 B. C. As yet, however, the Chaldean observations with which we are acquainted are reduced to the account of three eclipses of the moon that took place about 719 B. C. Hopes were entertained, when the discoveries of cuneiform tablets were made in the ruins of Babylonia and Nineveh, that trustworthy information of the real condition of astronomical science among the Chaldeans might be gathered from them; but it was some time before anything of this kind was realized. Messrs. Oppert and Sayce, it is true, found a few astronomical documents in the library of a king of Assyria, but they contained more astrology than astronomy, and were, moreover, too badly preserved to be of much use. Quite recently the Assyriologue, Father Strassmeyer, of the Society of Jesus, has found a few documents relative to astronomy in the Spartoli collection of the British Museum; and these have been carefully examined by Father Epping. They indicate that the Chaldeans had considerable knowledge of astronomy. Besides calculating the time of the new moon, and taking account of the thirds in their observations, they followed the courses of the planets, were acquainted with the retrograde movement of Mars, and referred the positions of the planets to those of the stars. If other results similar to these are at all extensively obtained from the immense amount of study yet to be made of the tablets, astronomers may hope to acquire materials of extreme value for the verification of their tables and the study of the system of the world.

Pedigree Selection in Food-Plants.—Major Hallett, in commending before the Brighton Health Congress his "pedigree system" for the improvement of food-plants, takes notice of the immensely greater advantages in favor of systematic improvement afforded by plants over animals. A cow or ewe, he says, "produces at birth one (or two) only; a single grain of wheat has produced a plant the ears of which contained 8,000 grains, all capable of reproduction. Now, we can plant all of these, and of the resultant 8,000 plants reserve only the best one of all, to perpetuate the race, rejecting every other." The principle of Major Hallett's system consists in applying this rule, of reproducing only the best plants of each lot in successive years. "Can anything approaching such a choice as this," he says, "be afforded any breeder of cattle or sheep, no matter how extensive his herd or flock?" Cereals, improved by Hallett's system, have now been cultivated in more than forty different countries in Europe, Asia, Africa, America, and Australia, with complete success everywhere, so far as reports have been received. A parcel of pedigree wheat taken to Perth, Western Australia, in 1862, where the average crop was ten bushels to the acre, produced from twenty-nine to thirty-five bushels to the acre, with seventy-two as the largest number of heads on one stool, and one hundred and thirteen grains in the largest ear. In 1881 the same wheat, or its descendant, produced, in New Zealand, seventy-two bushels on one acre; with more than ninety ears, some of them containing as many as one hundred and thirty-two grains each, on single plants. The same return—seventy-two bushels to the acre—was reported of three acres in Essex, England, in 1876, with one hundred and five ears, containing more than 8,000 grains, on one plant. Reports corresponding with this have been received from Brussières, France; Linlithgow, Scotland; Russia, Hungary, Italy, Holland, Denmark, and Sweden. The Hallett wheat withstood the frosts of 1875 and 1876 in Belgium, when other varieties were killed. In India, Sir Seymour Fitzgerald, Governor of Bombay, in 1870, reported the crop from the pedigree wheat to be fifty per cent greater in quantity and fifty per cent more valuable in quality than that produced from the best other seed that could be bought in the market. The same success has been obtained with barley and oats cultivated after this system. A friend of Major Hallett's, in Italy, applied his system to the sugar-beet, with the result of obtaining, after seven years of improvement, three times as much sugar and wine from the same acreage of roots as he had been accustomed to get at first. Experimenting with the potato, Major Hallett has started each year, for fourteen years, with a single tuber, the best of the year, cultivating for freedom from dis-

ease and for productiveness. Dividing the first twelve years of the fourteen into periods of four years each, he obtained for the first period an average of sixteen tubers from each single best seed-tuber; for the second period, nineteen; and for the third period, twenty-seven, or nearly double the yield of the first period. This plan of selection is on trial, in India, for cotton, and the reports so far received show already a marked difference in its favor.

The Mound-Builders in Mexico.—Mr. F. F. Hilder, in a paper on "The Archæology of Missouri," summarizes the results of the efforts of Mr. S. B. Evans to follow the works of the mound-builders down the Mississippi Valley, and connect them with the ancient works in Mexico. Beginning in Minnesota, Mr. Evans has, by personal survey, found an unbroken chain of these works along the great river to the Gulf, with colonies on the principal tributaries traversing the States that border on that stream. "Mounds were found along the entire route, and on the shores of the Gulf. Crossing into Mexico, the chain, dropped in the sea at Galveston, was recovered near Vera Cruz. On the plain of Cholula is a mound that, if transferred to Cahokia, would fit the landscape, and appear in general keeping with the works. On the other hand, if the great mound of Cahokia were brought in presence of Popocatepetl, it would not be abashed, but would be a fit companion of the pyramid. The pyramids of the sun and moon at Teotlihuacan would be mounds in Virginia and Ohio; and the great mounds of Grave Creek and Selzertown might embellish the 'ancient city of the gods.' Excavations were made in Mexican mounds, as they were made in the United States, and substantially the results were the same."

Elephant-Service in Africa.—Mr. L. K. Rankin, of the Belgian Elephant Expedition in Africa, has made a statement of the probable value of the practical service that may be expected from elephants if their introduction as carriers is attempted in that continent. When the expedition reached Mpwapwa, a report was drawn up to be sent to the King of the Belgians, which stated that "the elephant expedition has now been proved a complete success." This assertion was justified by Carter, the head of the expedition, now deceased, on the three counts of—1. The immunity of the elephants against the tsetse-fly after twenty-three days of exposure to that insect; 2. Their maintenance during one month mostly upon the uncultivated food of the country, and therefore at little cost (only about twenty-five rupees, or fifteen dollars, for four); and, 3. Their ability to march over all kinds of ground, soft, stony, sandy, boggy; to conquer all eccentricities of topography—hill and dale, river and jungle—while laboring under double their due weight of baggage, some fifteen hundred instead of seven hundred pounds; and this in a style that no other beast of burden could hope to emulate. This brilliant forecast received a seeming bitter contradiction in less than a week, when the largest and most valuable elephant, returning from a day's expedition, in apparently good health, suddenly lay down and died. Mr. Rankin believes that the death, which was followed shortly afterward by that of another elephant, was caused by exhaustion brought on by imposing too heavy loads and too severe labors upon the animal, combined with too great a change from the strong food it had enjoyed in India to the wild grasses of Africa. The animals had been stall-fed in India, "on the fat of the land," while in Africa they were turned out to forage for themselves, and very little corn and rice was bought for them. Whereas, according to Sanderson, seven hundred pounds is the limit-weight an elephant should carry on flat ground for a prolonged time, these animals bore at first twelve hundred, then fifteen hundred, and at one time seventeen hundred pounds; while they daily climbed the most tremendous hills. These views are enforced by the fact that, while the elephants were fat and round at starting, they had lost so much flesh by the time they reached Mpwapwa, that their backbones stood up six or seven inches from their flanks! These facts resulted from faults in management, in insufficiency of preparations for the expedition, and mistaken views of economy, and should not be allowed to prevail against the competency of elephants, under good management, to endure reasonable service, on which hardly any doubt is thrown. Dearly bought

experience, Mr. Rankin suggests, would another time remove the risks that were incurred; and he has not the shadow of a doubt that there is yet a great future in Africa for the elephant, especially when the stage of capturing and taming the native species has been reached.

Co-operation of Medical Officers and People in Sanitary Objects.—The Sanitary Aid Association of St. Leonard's and Hastings, England, during nine years of work among a population of thirty-five thousand, has secured a co-operation between the people and the sanitary officers, under which the spread of all infectious diseases has been effectually prevented. This it has done by tact in the exercise of its functions as a medium between the medical officers and the people. It seeks, first, to guard against popular jealousy of inquisitorial inspection. The teachers of the schools are expected to make weekly returns of all absentees, with the cause of absence if known; if the cause is not known, some fit person is deputed to make a friendly casual visit to the family, without any suggestion of suspicion of fever, and report the information received to whoever acts as sanitary manager. The case is then put into the hands of the health officer, and his endeavors are furthered by explaining to the mother that she shall receive, for the strict performance of the processes of disinfection taught her, assistance, to be allotted according to the circumstances of the family. The assistance may come in the form of a milk allowance, beef-tea, wine, or whatever may be ordered by the medical attendant, a nurse, or a person to do the washing, or, where no want exists, of little delicacies and comforts which may be given without offense. It should always be connected with obedience, by the persons assisted, of the inspector's orders, and should be accompanied, through the period of illness, by the promise of suitable help at the end. The greatest difficulties the medical officers have to meet arise from the desire of the poor to conceal their cases, for fear of injuring their business; but, under the operation of this system, every family that enjoys the benefit of its application and finds out what help and relief it gives tells the neighbors, and so it is brought about that the medical officer becomes himself the poor man's accepted friend. The St. Leonard's and Hastings society has never incurred a failure during all the years of its working; yet so unobtrusive have been its operations that one who should go down to inquire at random about it, without having a list of its allies, would have difficulty in discovering its existence. By adhering to and avowing the principle that it has no more right to interfere with the persons it visits than they with its members, by using persuasion and sympathy instead of threats, it has reduced the number of unmanageable cases to one a year; and has always brought even these around by taking care in conversing with the persons to give full information respecting disinfection. Thereupon, they turn around and act upon the information they have gained, so as to show how well they can do without their visitors.

Number of Species of the Orang-Outang.—The number of species of the orang-outang has been placed variously at from one to four. The upholders of the one-species theory have doubted whether the characteristics that were regarded as indications of specific differences might not really have arisen from the examination of skulls of different ages. To contribute to a solution of this doubt, Mr. Frederick A. Lucas has examined the large collection of orangs of Professor Henry A. Ward, and compared the notes taken by Mr. William T. Hornaday, while collecting orangs, and has satisfied himself that the views of the advocates of one species are correct. He previously believed that there were two species. He adds to his notes on the subject the suggestion that "they point clearly to the fact that it is extremely dangerous to form a species from observations of one or two skulls," and that they render it very probable that many fossil species have been based on individual or sexual peculiarities.

The Law of Land Formation on our Globe.—Professor Richard Owen, of New Harmony, Indiana, has observed some coincidences in the arrangements of continental lines and in the location and direction of elevations and depressions of the surface of the earth, which have suggested to him

a law by which dry land shows itself above the ocean, which he believes to be of almost universal application to geographical and geological phenomena. The coincidences which he describes may be traced by any one on a globe or a large map. The law, as Professor Owen has stated it in a paper on the subject presented to the American Association last year, is, in general terms: "The land on our globe shows itself above the ocean-level in definite multiple proportions, by measurement; the unit is the angular difference between the axis of revolution and the axis of progression. For convenience, as that angle has been lessening for centuries, we might call it 24°. We then have:

Geographical and geological unit........................ $= 24° = \frac{360°}{15}$
Greatest width and length of continents........... $= 3 \times 24° = 72° = \frac{360°}{5}$
Radius for continents..... .... $= 36° = \frac{360°}{10}$
Half radius " .... $= 18° = \frac{360°}{20}$

The measure for oceanic distances is the complement of $24° = 66°$. The ratio of land to water, as shown by Professor Dana, is as 100 : 275. The ratio of 24° : 66° : : 100 : 275. All measurements are to be estimated at the equator.

Regarding his law in detail, Professor Owen finds, first, that many longitudinal elevations and depressions on the earth's surface (the result apparently of cooling and contraction), especially near the greatest median—north and south—extension of each continent, coincide with some meridian. This shrinkage has caused a north and south continent to appear in each of the four quarters of the earth, going around on the equator. Minor north and south extensions can be traced at intervals, often of 4½° or 9° apart all around the globe, alternating usually with trends which form with them angles of 23½°. In verification of this law, adjust the globe so that the poles shall be at the wooden horizon and the eastern extremity of Brazil at the brass meridian. Then we shall find the two Americas occupying one, Europe and Africa the second, Asia and Australia the third, and North and South Oceania the fourth, of the quarters into which the rules divide the globe. It will be found that great elevations are matched by depressions on the opposite side of the globe, as the Himalayas and Central Asiatic table-land with Hudson Bay, the American lakes, the Gulf of Mexico, and the deep southeastern Pacific at 180° from them. A second feature is that the outlines of continents form angles of about 23½° with meridians. If we examine the great continental outlines, we shall find in the circuit of the globe five eastern trends of great continents exactly 72°, or one fifth of 360°, apart. These trends mark belts of seismic force, or lines apparently where the crust has less thickness than under the median lines of continents. The rule of trends may be verified by lifting the north pole of the globe 23½° above the wooden horizon and bringing the continental trends under the brass meridian. Professor Owen finds, third, that besides these two forces which exert their powers along lines parallel, respectively, to the axis of revolution and to that of progression, each continent has two foci nearly on its median line, concentric circles around which mark important additions to the land and orography of the continent, and pass, as they successively enlarge, through areas of consecutive geological periods from the older to the newer. One of the foci, and the dominant one in the northern continents, is near the Arctic Circle; the other is in the geographical center of the continent. The southern continents have only the latter. The foci for North America are in Boothia Felix, near longitude 96° west, and latitude 71° north, and near the height west of Lake Superior, longitude 94° west, and latitude 48° north. A radius of 24° from the northern focus reaches the southern limits of the archæan area near Lake Superior and its junction with the palæozoic; and one of 29° or 30° takes in the mesozoic of Kansas and the new red sandstone of Connecticut and Massachusetts, with a valley of erosion between. Drawing our circles from the west shore of Lake Superior, a radius of 11° or 12° gives us Silurian, lower and upper, from Niagara to near Springfield, Ohio, Lexington and Frankfort, Kentucky, and Nashville, Tennessee, dominating at least the eastern half of the circle, while the western part was still under water. A radius of 12° to 13° marks the Appalachian and other coal-fields; and of 15°, the mesozoic formation curving from the cretaceous of Utah and Colorado through the interme-

diate of Arkansas and Tennessee to that of New Jersey. A radius of from 18° to 24° takes in the marine tertiaries of the East and the West; one of 24° marks the main outlines of the continent; while one of 36° takes in the extreme points of the continent in all directions. The rule is applied with almost literal similarity to the other continents. Professor Owen furthermore maintains that the western Alps became a dynamic focus at about the beginning of the Cenozoic period, and that Monte Rosa is nearly the center of the dry land of the globe, whence a great circle of immense seismic activity may be traced nearly parallel with the Asiatic continental trend to the Himalayas and thence around to the Andes and the South American earthquake-region. Another great circle is nearly parallel to the North American trend, and includes the volcanoes of Central America and the geysers of Iceland, and incloses and probably aids to heat our Gulf Stream.

Value of Disinfectants.—Dr. George M. Sternberg, surgeon in the United States Army, has reported upon the results of experiments he has made with various disinfectants and vaccine virus, the conclusion drawn from which is that chlorine, nitrous acid (nitrogen dioxide), and sulphurous acid (sulphur dioxide), are reliable disinfectants in the proportion of one volume to one hundred volumes of air. Probably a considerably smaller proportion of these disinfectants would be efficient in destroying the potency of thin layers of virus in a moist state, or of virus exposed to the action of the disinfectant in an atmosphere saturated with moisture. Experiments with carbolic acid, on the other hand, "show that the popular idea, shared perhaps by some physicians, that an odor of carbolic acid in the sick-room or foul privy is evidence that the place is disinfected, is entirely fallacious, and, in fact, that the use of this agent as a volatile agent is impracticable, because of the expense of the pure acid and the enormous quantity required to produce the desired result."

A Selenium Photometer.—M. Léon Vidal has devised a photometric apparatus of selenium, for measuring the intensity of natural or artificial light by means of an action purely physical and mechanical, and in a manner analogous to that by which we measure the temperature and the amount of atmospheric pressure with the thermometer and the barometer. The difference in conductibility which results from the action of light on selenium produces deviations in the needle of the galvanometer which correspond in extent with the intensity of the luminous source. In this manner we may determine, at a glance, the intensity of light at any instant. The principle is applied to the construction of meteorological photometers, for which elements of selenium of equivalent conductibility are provided, to be substituted for each other as their molecular condition becomes modified; the plates may be restored to their normal condition by heating them, and used again. This instrument may be employed for the rapid and visible record of the instantaneous changes in luminous intensity, at all heights and depths, the observer reading the indications of the galvanometer at the place which may be most convenient for him.

NOTES.

The American Public Health Association will hold its tenth annual session at Indianapolis, Indiana, October 17th to 25th. Papers will be presented on the different action of disease in the white and black races, the removal of excreta, heredity, sanitary associations, vaccination, intermittent fever in New England, sanitary organization, cattle-disease, etc., etc., with reports of committees on the prevention of venereal disease, compulsory vaccination, the management of epidemics, statistics, cattle-diseases, National Museum of Hygiene, incorporation of the Association, and necrology.

The American School of Classical Studies at Athens, Greece, under the direction of a committee of the Archæological Institute of America, is to be opened on the 2d of October. Its object is to promote the study of classical literature, art, and antiquities, by graduates of American colleges, and to prosecute and aid original and co-operative research in those subjects. The school is open, free of fees, to bachelors of arts, properly recommended from co-operating colleges. Nine colleges in New England, New York, New Jersey, and Baltimore, have contributed annual subscriptions of $2,250, most of them for ten years, in aid of the school.

Dr. H. P. Stearns, of the Hartford (Connecticut) Retreat for the Insane, accounts for the increased amount of disease of the nervous system observed of late years, by reference to the larger part of the twenty-four hours which the masses of the people spend within-doors. A far greater part of the population than used to be are employed in counting-houses, business-offices, stores, and factories, inhaling a heated and contaminated atmosphere, the effect of which upon the delicate structure of the brain can not but be most unfavorable.

Mr. H. W. S. Cleveland, in his important pamphlet on "The Culture and Management of our Native Forests," says that we must learn to imitate Nature in our methods of cultivation, if we would grow new forests successfully. The primary point is to keep the trunks of the trees shaded. Nature does this by massing the plants closely together in the forests, so that they shade each other, or by giving a wide spread of limbs with low heads to trees in the open. It also protects the cambium layer with thick deposits of old bark, and we endanger the health of the tree when we scrape this off. Another important point is to keep the roots well mulched, as nature does with old leaves, thick mold, and mosses in the forest; and a third point is to protect the trees well from the southwest wind—the breeze which, with its drying heat, is the most damaging to the vitality of the tree. In illustration of the validity of this rule Mr. Cleveland points to the greater luxuriance and variety of plant-life on the east side of seas and lakes than on the west side.

Professor Francis Maitland Balfour, of the University of Cambridge, lost his life about the 19th of July, while attempting the passage of the Aiguille Blanche de Penteret, one of the buttresses of Mont Blanc, in Switzerland. He was only about thirty years old, but had done a very large amount of original biological work for one so young. Having entered Trinity College, Cambridge, as a natural science scholar, he decided, upon the suggestion of Professor Michael Foster, to apply himself at once to original work instead of going through the ordinary routine preparation for his degree. He was afterwards engaged at the zoölogical station at Naples, and then at Naples and Cambridge alternately, and had just been honored by the creation of a special chair of Animal Morphology for him at the university. He was the author of a work of eminent merit on the "Development of the Elasmobranch Fishes." and had begun a work on "Comparative Embryology."

The English unit, or parliamentary standard, for the estimation of the intensity of light, is a spermaceti-candle, six to the pound, burning 120 grains an hour. The French standard, or carcel, a lamp burning 42 grammes of refined colza-oil per hour, with a flame 40 millimetres high, is reckoned as equivalent to 9·5 candles. The English standard for gas-lights is an Argand burner with sixteen holes, in a chimney five inches high and two inches in diameter, burning five feet of standard gas per hour, and giving a light of sixteen candles. The German standard, or *Vereinskerze*, is a paraffine-candle 20 millimetres in diameter, with a flame five centimetres high, 7·6 of which are equivalent to a carcel. The variations of the carcel burner do not exceed two or three per cent, while those of the standard candles sometimes rise to thirty per cent.

The later experiments of Professor W. O. Atwater and his aids on the effects of fertilizers and the feeding capacities of plants, as recorded in a paper just published by the Agricultural Department, indicate that Indian corn has a much greater power of gathering nitrogen from the soil or air or both than it has been credited with; that in this respect it comes nearer to the legumes than to the cereals; and that it may eventually claim a right to be classed with the "renovating" crops. The experiments are, however, not yet considered decisive. Professor Atwater, projecting a plan for continued experiments in the line to which his report is devoted, suggests that chemical and physical surveys of the land in behalf of agriculture ought to be undertaken, just as there have been topographical and geological surveys in behalf of other industries and interests.

The death is announced, July 16th, of Dr. George Dickie, Professor of Botany in the University of Aberdeen, Scotland, for seventeen years, and previously for several years in the Queen's College, Belfast. He retired from active duty, on account of impaired health, in 1877. He was the author of numerous papers and several books on botanical subjects. He was especially interested in the study of algæ.

Professor William Stanley Jevons, the philosopher and Professor of Political Economy, was drowned while bathing at Bexhill, near Hastings, England, August 15th. Professor Jevons was a grandson of William Roscoe, the merchant author, and was born in Liverpool, in 1835. He was connected with the Royal Mint at Sydney, Australia, for five years after 1854, and was appointed Professor of Logic and Moral Philosophy and Lecturer on Political Economy in Owens College, Manchester, in 1866, and Professor of Political Economy in the University of London in 1872. He was the author of several works in logic and political economy, which are recognized as authoritative.

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Books noticed:

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